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Life cycle of estuarine islands — From the formation to the landlocking of former islands in the environs of Miletos and Ephesos in western Asia Minor (Turkey)

Helmut Brückner [a,*], Alexander Herda [b,c], Michael Kerschner [d], Marc Müllenhoff [e], Friederike Stock [a]

[a] University of Cologne, Institute of Geography, Germany
[b] Humboldt University of Berlin, Institute of Classical Archaeology, Germany
[c] National & Kapodistrian University of Athens, Faculty of History and Archaeology, Greece
[d] Austrian Archaeological Institute, Austrian Academy of Sciences, Vienna, Austria
[e] Geo-present, Korbach, Germany

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ABSTRACT

The focus of this article is to link historical accounts about former islands of the Anatolian gulfs of the Aegean Sea to geoarchaeological evidence. During the Holocene, prominent environmental and coastline changes have taken place in many tectonic grabens of western Asia Minor, today's Turkey. The Büyük and the Küçük Menderes fault systems are excellent examples for deciphering these changes. Since mid-Holocene times, the eponymous rivers have advanced their deltas, silting up marine embayments which had once reached inland for tens of kilometres. To describe this terrestrial–marine–terrestrial evolution of estuarine islands we coin the term "life cycle of estuarine islands". Besides other factors, such as natural erosion, sea-level changes, and tectonic activities, the delta progradation was mainly governed by riverine sediment load, which, in turn, was to a great extent dependent on human impact on the vegetation cover of the drainage basins. Based on historical accounts as well as modern geoarchaeological research it is possible to reconstruct the spatio-temporal evolution of the landscape.

For Miletos and the Büyük Menderes (Maiandros, Maeander) graben, remarkable transformations have been revealed: the metamorphosis of the marine gulf into residual lakes (Lake Azap, Lake Bafa), the landlocking of islands (Hybanda, Lade, Asteria, Nergiz Tepe), the transition of the Milesian archipelago to a peninsula and finally to a part of the floodplain. A dramatic effect of the ongoing accumulation of fine-grained sediments was the siltation of harbours – a major reason for the decline of the once flourishing coastal cities of Myous, Priene, Herakleia, and finally Miletos, today some 8 km inland.

For Ephesos and the Küçük Menderes (Kaystros) graben, the research focused on the former island of Syrie. Pliny the Elder (*Naturalis Historia*, c. CE 77) attributed the landlocking of Syrie to the Kaystros River – a scenario which has been verified by our geoarchaeological research and ^{14}C–dated to the 5th century BC. The local foundation myth according to which an island, presumably Syrie, was the location of the first settlement of immigrants from the Greek mainland in the 11th century BCE can neither be proven nor disproven for lack of archaeological evidence. The delta advance was the main reason why the settlement sites and the harbours of Ephesos were relocated several times from the Early Iron Age to the Middle Ages.

1. Life cycle of an estuarine island

During the Last Glacial Maximum (LGM) c. 20,000 years ago, when worldwide the ice sheets as well as the permafrost regions had evolved to their maximum extent, sea level had glacio-eustatically fallen ~120 m below its present position (e.g., Waelbroeck et al., 2002; Peltier and Fairbanks, 2006). At this time, more than half of the continental shelves were exposed and comprised dry land. The effect was especially dramatic in regions with shallow shelves (cf. Sakellariou and Galanidou, 2016).

Ensuing global warming caused a rapid marine transgression at an average speed of more than 10 m in 1000 years (between 17 and 7 ka BP), which was even more rapid when so-called meltwater pulses occurred. Palaeolithic and Mesolithic humans experienced this rapid sea-level rise by the extensive drowning of parts of their game areas and the interruption of their migratory routes.

One effect of the marine transgression was that islands were "born" when, depending on the topography, some parts of the land became separated from the mainland. This holds true for many islands of the Aegean Sea, a prominent case being Samos.

Another effect of the sea-level rise was the marine flooding of river mouths. Thus, gulfs evolved which reached far inland, sometimes for

* Corresponding author.
E-mail address: h.brueckner@uni-koeln.de (H. Brückner).

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tens of kilometres, giving birth to another series of islands, those in estuaries. According to Klug's (1985) typology of islands, they belong to the group of "Drowning Islands", a subsection of the "Ingression Islands". If they form part of a ria coast, we suggest the term "Estuarine Islands".

The considerable deceleration of the transgression around 7000 years ago led to the formation of deltas (see also Stanley and Warne, 1994), thus reversing the direction: from the landward to the seaward shift in the shoreline. The speed of the delta advance was dependent from the configuration of the embayment with its specific accommodation space, mid- and late Holocene sea-level changes and tectonics. The major factor, however, was the availability of sediments, which, in turn, was dependent from the erodibility of the rocks in the drainage basin, the carrying capacity of the rivers, the sediment input by coastal currents, and, last but by no means least, human impact on the vegetation cover in the drainage basins as the major trigger of erosion (Brückner, 1986).

Delta progradation led to the silting up of the marine embayments. In many cases this caused the landlocking of the estuarine islands. "Death" came, when the delta front had reached the island, thus turning it into a peninsula. Landlocking could also happen when littoral currents created a tombolo, which connected the island with the mainland. The island's "life cycle" was completed when the delta front had passed by, causing its total integration into the floodplain of the river. Already in the 5th century BCE, the historian Thucydides correctly identified siltation by the river Acheloos as the main reason for the landlocking of the Echinades islands:

"Opposite to Oeniadae lie most of the islands called Echinades, so close to the mouths of the Achelous that that powerful stream is constantly forming deposits against them, and has already joined some of the islands to the continent, and seems likely in no long while to do the same with the rest." (*History of the Peloponnesian War* 2.102.3; transl. R. Crawley, 1874).

This palaeogeographic scenario was confirmed by geoarchaeological evidence (cf. Vött et al., 2007). That siltation was the fate of several islands was also observed by Pliny the Elder (CE 23–79). In his encyclopaedic "Natural history" he writes:

"Again she [*natura*, 'nature'] has taken islands away from the sea and joined them to the land—Antissa to Lesbos, Zephyrius to Halikarnassus, Aethusa to Myndus, Dromiscos and Perne to Miletus, Narthecusa to Cape Parthenius. Hybanda, once an Ionian island, is now 200 stadia distant from the sea, Ephesus has Syrie as part of the mainland, and its neighbour Magnesia the Derasides and Sapphonia." (*Naturalis historia* 2.204; transl. H. Rackham, 1967).

For this Holocene process – the "birth" of an island in the course of the postglacial sea-level rise, its flourishing time ("life span") as an island, the shores of which are exposed to marine waves, and its "death" when fluvial siltation becomes dominant with the result of landlocking – we coin the term: "life cycle of an island". This is especially the fate of estuarine islands, which are part of the coastal metamorphosis from a ria coast to a delta coast.

2. The study area

Due to the westward drift of the Anatolian Microplate and the availability of sufficient accommodation space, Western Anatolia is tectonically characterized by horsts and grabens. The latter render the natural depressions for the river courses, e.g., the Büyük Menderes, the ancient Maiandros (*Nomen est omen!*) and the Küçük Menderes, the ancient Kaystros.

The dramatic coastline changes described above holds particularly true for the Mediterranean, and especially for western Anatolia (Kayan, 1999). About seven millennia ago, the maximum transgression of the sea had inundated the Büyük Menderes (Maiandros) graben for at least 25 km inland (Müllenhoff, 2005: 8, 187 f.; even for 60 km according to Bay, 1999: 27 f.), and the Küçük Menderes (Kaystros) graben for c. 20 km inland (Brückner, 2005; Stock et al., 2015). Thereafter, the progradation of the deltas of these rivers and their tributaries has continuously shifted the coastline westwards. The outcome was the prominent metamorphosis from a ria coast to a delta coast: the present-day bird's foot delta of the Büyük Menderes, and the blocked delta of the Küçük Menderes. Important harbour cities, such as Miletos and Ephesos, which were located in the graben systems, fought against siltation with different weapons (dredging, damming, construction of a canal, relocation of harbours) – it was, however, a battle that could not be won.

3. Methods

For reconstructing the former geographies of the environs of Miletos and Ephesos, i.e. the Milesia and the Ephesia, we combined historical accounts and evidence from archaeological excavations with geoarchaeological results (including geophysical images, geological data, interpretation of maps and satellite images). Since the beginning of the 1990s, many drill cores have been retrieved from the geo-bio-archives, such as alluvial plains, deltas, harbours, silted-up lakes, and swamps. The samples were analysed according to their geochemical, sedimentological, faunal and floral properties (cf. Stock et al., 2014; for the geoarchaeological research design see Brückner, 2011). In many cases, coring in the study area followed the geophysical research. The georadar, geomagnetic, and geoelectric images provided first impressions of the subsurface strata. The interpretation of these data was then tested by coring. At very promising sites archaeological excavations were carried out; this is of course the "master discipline", but also the most expensive and time-consuming effort, and in cases where groundwater table is high, it affords a costly drainage system.

The synopsis of all of these data leads to the spatio-temporal reconstruction of the landscape evolution, and sheds light on the human-environment interactions – and in particular on the life cycle of the former islands. When describing them in detail, it is evident that the explanatory notes on those of the Büyük Menders graben are richer than those of the Küçük Menders graben. Due to the much bigger size of the Maiandros graben, it once hosted more than a dozen islands, while the Kaystros graben hosted only one prominent island (Syrie). This imbalance is reflected in the following sections.

4. The Büyük Menderes (Maiandros, Maeander) and Miletos – delta progradation, demise of islands, silted-up harbours

The tectonic graben of the Büyük Menderes (Maiandros, Maeander; see Herda, 2013a) is flanked to the north by the nearly 1300 m high mountain range of the Mykale (modern Dilek Dağları, formerly also Samsun Dağı), consisting of limestones and schists, to the south by Neogene marl- and limestones, and to the southeast by the granite and gneiss massif of the Latmos Mountains (modern Beşparmak Dağları), which reaches up to 1332 m. In the river's drainage basin loosely consolidated Neogene rocks and weathered Palaeozoic mica schists outcrop; they have a high erosion potential, wherefore the Menderes alluvia are very rich in mica.

Geoarchaeological research in the Milesia started in the 1990s: for Miletos and the lower Maeander valley see Brückner, 1995, 1996, 1997a, 1998, 2003; Brückner et al., 2002, 2006, 2014a, 2014b; Schröder, 1998; Bay, 1999; Müllenhoff, 2005; Müllenhoff et al., 2009; Herda et al., 2017). In this article we focus on the former islands that had existed in the Ikarian/Karian gulf. The diverse and manifold material of the Büyük Menderes graben and Miletos will be presented in three sections: the Maeander delta progradation as a whole (Section 4.1); the islands which became landlocked (Section 4.2); and new insights into the palaeogeography of the former Milesian archipelago (Section 4.3).

4.1. Reconstructing the delta advance

4.1.1. Delta advance according to geoarchaeological evidence

The typical coring profile – as documented, for example, in the later discussed Figs. 7 and 15 – starts with transgression facies (pebbles, coarse sand), lying with erosional disconformity on the pre-Holocene bedrock. These deposits were accumulated in a littoral environment, when the post-glacial marine transgression had reached the coring site (1st transition of the shoreline). With the continued rise in sea level, the environment turned into shallow marine, as evidenced by finer-grained strata (fine sand, silt) and a milieu-specific fauna. The fining-upward sequence may be reversed during the following regression. The 2nd transition of the shoreline may be expressed by coarse-grained material (pebbles, coarse sand), indicating a littoral environment. If, however, a sandbar has evolved seawards, a lagoonal environment is created at the coring site with very fine-grained deposits (clay) and a typical faunal association. In most cases, the top of the profile comprises alluvium, deposited by the river and its affluents during floods.

Fig. 1 shows the scenario for the spatio-temporal advance of the Maeander delta in eight time slices: 1500 BCE, 800 BCE, 300 BCE, turn of the eras, CE 300, CE 100, CE 1500, and the present situation. This interpretation is based on c. 300 percussion corings similar to the one described above. The depositional environments and their changes are deduced from the faunal associations (esp. ostracoda and foraminifera), which in turn leads to the reconstruction of the coastal changes. The chronostratigraphy relies on radiocarbon (^{14}C) age estimates, archaeological as well as historical evidence (details in Müllenhoff, 2005). We shall come back to Fig. 1 several times when discussing the many former estuarine islands of the Ikarian/Karian gulf.

4.1.2. Delta advance according to literary sources

Deltaic growth has been described in ancient literary sources. Pausanias (later 2nd century CE) correctly explains the reason why the inhabitants of Myous had given up their city and had re-settled in Miletos: the deposits of the Maeander had cut off a former marine inlet so that a coastal lake evolved; after freshening it became the breeding place for mosquitoes, which made living in Myous unbearable.

"The Ionians who settled at Myous and Priene, they took the cities from Karians. (…) The people of Myous left their city on account of the following accident. A small inlet (κόλπος) of the sea used to run into their land. This inlet the river Maeander turned into a lake (λίμνη), by blocking up the entrance with mud (ἰλύς). When the water, ceasing to be sea, became fresh, gnats (κώνωπες) in vast swarms bred in the lake until the inhabitants were forced to leave the city. They departed for Miletos, taking with them the images of the gods and their other movables; and on my visit I found nothing in Myous except a white marble temple of Dionysos." (Pausanias, *Description of Greece* 7.2.10–11; transl. Jones and Ormerod, 1918).

A few passages later the same author describes the major environmental change from a former marine gulf into arable land resulting from the siltation of the river (for the position of the contemporaneous shoreline see Fig. 1, scenario between the turn of the eras and CE 300):

"My reasoning is confirmed by the fact that the Maeander, flowing through the land of the Phrygians and Karians, which is ploughed up each year, has turned in a short time the sea between Priene and Myous into solid land." (Pausanias, *Description of Greece* 8.24.11).

To whom did the newly created land belong? An inscription found in Miletos sheds light on this important issue: in the time of Roman emperor Augustus (31 BCE – CE 14), the Milesian Caius Iulius Epikrates gained permission from Augustus to take possession of "the land newly turned to earth by the Maeander, and the sandbanks" (τὴν ἀπ[ο]γαι[ου]μένην χώραν ὑπὸ τοῦ Μαιάνδρου | καὶ τοὺς γαιῶνας).

He did this in the name of the city of Miletos, who honored him with a statue in the gymnasium in return (Herrmann, 2006; Brückner et al., 2014a: 86). This new land as well as the profitable fisheries in the lagoons along the coastline, were either located north of Miletos, in the

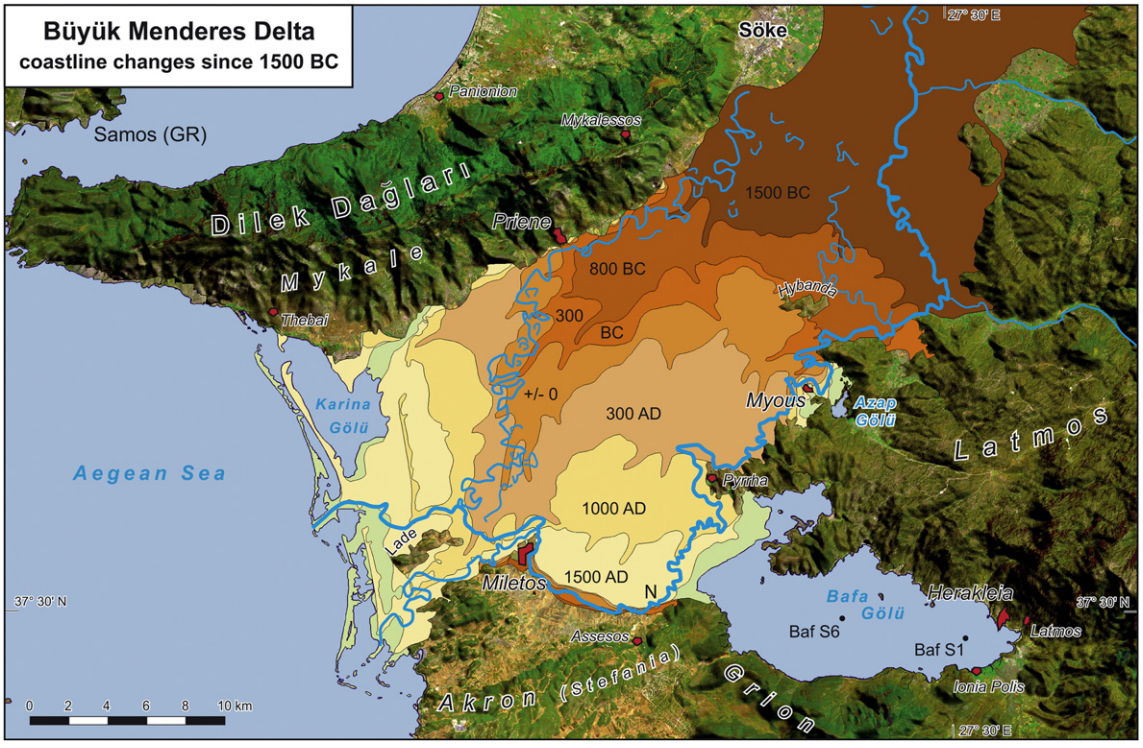

Fig. 1. Progradation of the Büyük Menderes (Maiandros, Maeander, Meander) delta since 1500 BCE As for the general topographic situation see inserted map in Fig. 10. The advancing delta front has continuously shifted the shoreline towards the southwest, infilling the former marine embayment. Bafa Gölü has not been silted up since the delta bypassed this region and sediment input from the adjacent mountains is low. The former islands of Lade, Hybanda, and Nergiz Tepe (N) are noted. Source: Müllenhoff, 2005.

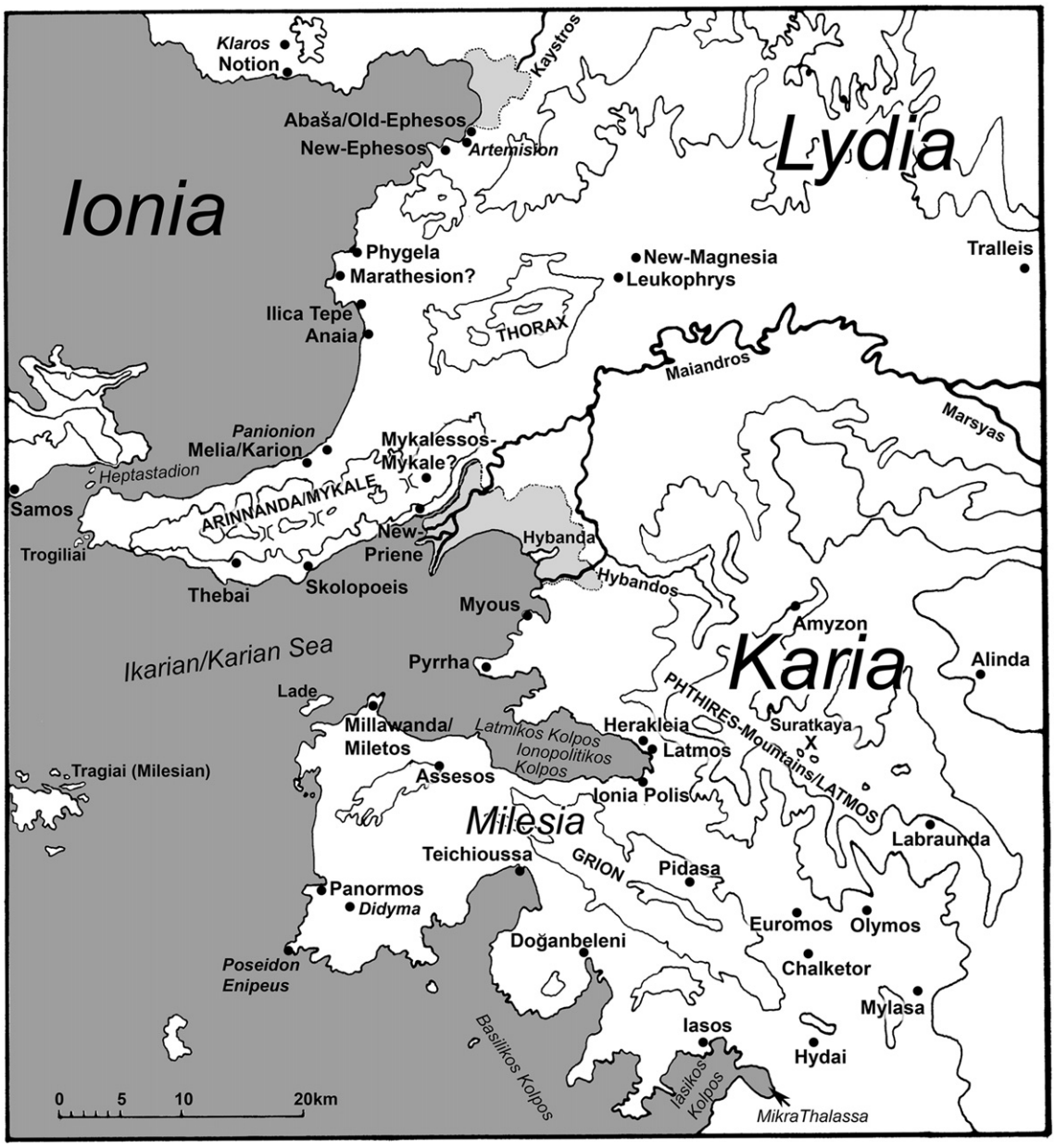

Fig. 2. Historical topography of southern Ionia with adjacent parts of Lydia and Karia. The shoreline is that of the Late Geometric Period (c. 700 BCE), the lifetime of Homer. Light grey: approximate area of the later Kaystros and Maiandros deltas still occupied by the sea c. 1500 BCE, at the end of Minoan dominated Miletos IV and the beginning of Mycenaean dominated Miletos V. Source: Herda, 2009, 45 Fig. 3; supplemented by Herda et al., 2017.

delta area of the "Old" Maeander approaching from Priene, wherefore both cities had been in rivalry about their ownership (Thonemann, 2011: 322 f., 334), or it had accumulated at the mouth of the "New" Maeander west of Myous and became disputed between Miletos and its other adversary in the lower Maeander plain, Magnesia.

4.2. Former islands in the gulf of Miletos

4.2.1. Hybanda

Hybanda bears a pre-Greek, indigenous Anatolian-Luwic name (Zgusta, 1984: 647 § 1395 Hybanda). Already in 1775, Richard Chandler convincingly identified it with a 40–70 m high group of four hills at the modern village of Özbaşı, c. 13.5 km south of today's Söke and 4 km northeast of the ancient city of Myous (Chandler, 1775: 178).

Hybanda (Figs. 1, 2, 3) is among the islands enumerated by Pliny in his famous account mentioned above. It became landlocked by the Maeander alluvium already in Late Geometric times (late 8th century BCE, see Müllenhoff, 2005) (Fig. 2). By then, Homer performed his Greek-Ionian epic *Iliad*, singing of the Karians of Miletos who own the mountains of Mykale as well as Latmos (*Phthiron oros*) and "the streams of Maeander" (*Maiandrou te rhoas*; Homer *Iliad* 2.869; cf. Herda, 2009: 37–45) – the plural may hint to bifurcation, a typical phenomenon of deltas.

It is amazing that the tradition of this former island survived for such a long time. The reason may have been that the winter floods of the Maeander turned Hybanda into an island again; this was still the case until the early 20th century CE (see Wiegand, 1929, Beilage). Plus, the Hellenistic designation *Hybandis* for the territory (*chora*) around the former island (Lohmann, 2006: 199) points to an unbroken settlement activity in ancient Hybanda, a few traces of which were found west of the modern village of Özbaşı (Lohmann, 2006: 198, 254 Fig. 3 "Felsbettung"). The knowledge about the former island of Hybanda will therefore have survived as part of a local tradition, Pliny could rely on.

Nevertheless, the 200 stadia (36 km) the author mentions as being the distance between Hybanda and the open sea are "l'exagération rhétorique" (Robert, 1959: 23 f.): in reality it amounted to only 112 stadia (20 km) during his lifetime (Müllenhoff, 2005: 197 Fig. 51). Even today the said distance is only c. 150 stadia (27 km) (Müllenhoff, 2005: 214 Fig. 56) (Fig. 1).

The "Hill of Hybanda" (⟨*Hyb*⟩*andios lophos*) was the site of a battle in 428/427 BCE. An Athenian expeditionary force under the command of Lysikles had landed in the harbour of Myous and started to march up the Maeander plain to collect the tribute from their Karian 'allies', when they were attacked and defeated by a united Karian-Anaiïtian army near the hill (Thucydides 3.19.2 has *Sandios lophos*; for emendation see Rayet and Thomas, 1877: 25 n. 1. p. 27; Herda et al., 2017: chap. 5 with n. 198 f.). By then, the former island must already have been at least partly integrated into the delta plain by the sediments of the southern branch of the Maeander (today's Büyük Menderes) and its tributary, the Hybandos (today's Kısır Çay) which joins the main river 4 km to the west of Hybanda.

After the city of Myous had been given up by her inhabitants (cf. chap. 4.1.2), the Hybandos river became the border between Magnesia and Miletos in c. 185/4–180 BCE. The surrounding land of the *Hybandis*, formerly in possession of Myous, fell to Miletos which integrated the Myousians into her own citizen body. A peace treaty ended the long period of 'alluvium wars' between Magnesia and Miletos for the newly accumulated lands (A. Rehm in: Kawerau and Rehm, 1914: 341–349 no. 148 lines 28–38 [peace treaty]; cf. Herda et al., 2017: chap. 5 with n. 189–194).

4.2.2. Lade

Lade is first mentioned by the Milesian geographer and ethnographer Hekataios in his "Journey round the world" (*Periegesis*/*Ges Periodos*) c. 500 BCE (*Die Fragmente der griechischen Historiker (FGrHist)* 1 F 241). The name *Lade* (Λάδη) or in its elder form *Late* (Pliny, *Naturalis Historia* 5.135) may be, like Hybanda and Maiandros, of indigenous Anatolian origin (Bürchner, 1924: 381; Herda, 2009: 99).

Lade, today's Batmaz Tepeleri ("the unsinkable hills", see Brückner et al., 2014a: 86 with n. 155; Brückner et al., 2014b: 795 with n. 65), is nowadays part of the delta plain, up to 99 m high and 3 km long. It is situated 2 km east of the coastline and 2.5 km west of Miletos (Fig. 4). In ancient times, the closest distance between the island and the coast was c. 1.3 km (Tuttahs, 2007: 339). Geologically, Lade consists of freshwater limestone (Neogene Akbük formation); it is a tectonic block which had slid into the Maeander graben (Müllenhoff, 2005: 23; Tuttahs, 2007: 30–32). Due to its prominent position at the southern entrance to the marine gulf as well as its proximity to Miletos, Lade was the strategic key to control the access to Miletos and the other harbour cities of the region. So far, archaeological work has been restricted to an extensive survey, and nearly nothing is known about the settlement history of Lade (Lohmann, 2006: 204 f. s.v. Lade).

In several naval battles, the island played a decisive role. In the famous "Battle of Lade" in 494 BCE, the victorious Persians ended the Greek-Ionian rebellion against their rule. The mid-5th century BCE historian Herodotus reports this battle as follows:

"These [the Ionians], when they came to that place [the Panionion] and there consulted, resolved to raise no land army to meet the Persians, but to leave the Milesians themselves to defend their walls, and to man their fleet to the last ship and muster with all speed at Lade, there to fight for Miletos at sea. This Lade is an islet (*nesos mikri*) lying off the city of Miletos." (*Histories* 6.7; transl. Godley, 1975).

In 334 BCE, the occupation of Lade by the Macedonian fleet preluded Alexander's conquest of Miletos, as the 2nd century CE historian Arrian describes it in his *Anabasis* (1.18.4–5; cf. von Graeve, 2000: 118. 121. 124 f.). Alexander's troops occupied the island of Lade and

Fig. 3. View from today's Güllübahçe (village in the foreground) at the southern slope of Dilek Dağları (Mykale Mountains), immediately east of ancient Priene, towards southeast via the floodplain of the Büyük Menderes (Maiandros) (M). On the southern side of the valley the former island of Hybanda (H) is visible in front of Beşparmak Dağları (Latmos Mountains) (LM). The area of the valley floor, which has been intensively cultivated (green and yellow fields) since the installation of an irrigation-drainage system in the 1950s, was once part of the extended marine embayment of the Ikarian resp. Karian Sea. The course of the "Old" Maeander (OM) is seen in the middle- and foreground (greenish yellow meandering (!) line). Photo: M. Müllenhoff, August 1999.

the strait between Lade and the opposite mainland to cut off the Persians and Phoenicians in besieged Miletos from help by the Persian fleet:

"Nicanor, however, bringing up the Greek fleet, reached Miletus three days ahead of the Persians, and anchored at the island of Lade with 160 ships. Lade is over against Miletus. The Persian fleet were too late, and when their commanders learnt of Nicanor's arrival already at Lade, they anchored under Mycale." (*Anabasis* 1.18.4–5, transl. P.A. Brunt, 1976).

In 200 BCE, another naval battle was fought at the island of Lade: the one between the Rhodians and Philip V (Polybios 16.15.6; cf. Brückner et al., 2014a: 68).

The landlocking of Lade started in the Late Roman period, when the northern branch of the Maeander, the Eski Menderes ("Old Maeander"), approached the Milesian peninsula (Fig. 1). In the mid-4th century CE, the governor of Asia, Skylakios, had to build "a canal through the plain"; he also "turned the Maeander back into a natural course" and "restored the harbours to the city" of Miletos (Himerios *Orationes* 25.73–95; cf. Thonemann, 2011: 318 f.; Brückner et al., 2014a: 87, Brückner et al., 2014b: 796). By then, Miletos' access to the open sea was already reduced to the small strait between Lade and the mainland in the south (cf. Fig. 4). In the following half-millennium, a lagoon developed northwest of Lade, and by c. CE 1000 the sediments of the "Old" Maeander (the term is first used in 13th century CE acts of the monastery of St John the Theologian on Patmos; Tomaschek, 1891: 36) landlocked the eastern part of the island (Müllenhoff, 2005) (cf. Fig. 1).

Around that time, in CE 1073, the island together with a village on it called *Galaidai* as well as other estates in the lower Maeander plain had been given by the Byzantine emperor Michael VII Doukas to his cousin Andronikos Doukas. In this context the name Lade appears for the last time in the acts of the monastery of St John the Theologian on Patmos (*Patmos* II.50 line 167; cf. Thonemann, 2011: 263. 260 map 11). In CE 1216, the monastery of St John successfully addressed the emperor Theodore I Lascaris to get the lands around *Pyrgos*, "tower", as is was called by then after a medieval round watch tower located on the middle hilltop of former Lade at 72 m a.s.l. (Wilski, 1906: map, quadrant C4 "m-a Rundbau"; Thonemann, 2011: 264 n. 66).

The Pyrgos estate which became more and more integrated into the newly accumulated terrain, is described in the monastery's acts as being "the land which lies between the two rivers, the Maeander and the river flowing from *Palatia* [i.e. Miletus]" (*Patmos* II.61 line 19; cf. Ragia, 2009: 42. 198 f. with n. 847; Thonemann, 2011: 263 f. with n. 66). This is a clear indication that the main branch of the northern "Old Maeander" emptied north of former Lade. The second river "flowing from Palatia" may likely have been a minor branch of this "Old Maeander" which had found its way between the Milesian peninsula and Lade, and started to close the strait between the former island and the mainland, once called in the acts also "the narrow of Palatia" (*Patmos* I.14 lines 22 f. ἐγγὺς τῶν Παλατίων; cf. Thonemann, 2011: 264 n. 66).

Patmian ownership of the *Pyrgos*-lands around Lade was acknowledged by the Ottoman emperor Mehmet II in CE 1454 (Ragia, 2009: 199 χωριό της Πάτμου), who also granted the monastery, called *Batnos* by the Turks, administrative independence and immunity from attacks (Thonemann, 2011: 290 f.). Even when the extremely profitable salines, located in the lagoon northwest of former Lade and the mouth of the "Old Maeander", which had been part of the *Pyrgos* estate, became property of the Ottoman state in the 16th century CE, they kept their old owners name, "*Batnos* saltpans" (Thonemann, 2011: 328 f.). The 19th century CE Ottoman Greek village *Pat(i)niotiko* equally preserved the Patmos-link (Lohmann, 2006: 235 f.), as does the modern Turkish Batmaz Tepeleri, a folk etymology related to the fact that the hills of former Lade "do not sink" (Turkish *batmaz*) during the winter floods (Brückner et al., 2014a: 86 n. 155).

4.2.3. Asteria and the grave of Asterios

According to the ancient travel guide Pausanias (mid-2nd century CE), Lade was surrounded by some detached islets. One of them was Asteria, "the Starry" or "Comprised of Stars". It gained some fame as being the place of the tomb of the autochthonous Asterios, the son of the giant Anax (Wernicke, 1896; cf. Herda, 2013b: 90 f.):

Fig. 4. View from the theatre of Miletos on the up to 99 m high hills of the former island of Lade (Batmaz Tepeleri) (L). To the right (north) the Maeander plain, to the left (south) the 1.3 km broad former strait between Lade and the mainland. Photo: H. Brückner, 25.09.2015.

"Before the city of the Milesians is an island (*nesos*) called Lade, and from it certain islets (*nesides*) are detached. One of these they call the islet of Asterios, and say that Asterios was buried in it, and that Asterios was the son of Anax, and Anax the son of Earth. Now the corpse is not less than ten cubits." (*Description of Greece* 1.35.67; transl. Jones and Ormerod, 1918).

Pausanias seemed to have visited the site personally, where he was shown the remains of Asterios. The small size of the corpse (*nekros*), obviously too small for the son of a giant, provoked his ironic remark "not less than ten cubits (5 m)".

Asteria is likely to be identified with a 22 m high rock less than 1 km west of the village of Pat(i)niotiko, today's Batı Köy ("West Village") on the eastern slopes of the former island of Lade (Fig. 5), an identification already proposed by Olivier Rayet, the first excavator of Miletos (1873–1874), in 1877 (Rayet and Thomas, 1877: map. pl. 2 "I. Astérion"). The distance to Miletos adds up to 2.5 km. In early 20th century maps, this small hill is named in Turkish *Mezar Tepe*, "Hill of the Graves" (Wilski, 1906: map, quadrant C3 "Mesartepe"; Philippson, 1936: map, "Mesartepe"). It seems, however, as if the graves on Mezar Tepe are modern and not ancient. They are not distinguished from those in the graveyard of today's Batı Köy. Furthermore, ancient ruins or graves are otherwise designated in red on the map. Today, no remains of these graves have survived. The limestone of the hill has been extensively quarried for building a 15 km long asphalt road through the Maeander plain, connecting Miletos-Balat with Tuzburgazı at the foot of the Mykale Mountains. The landlocking of Asteria by the alluvia of the "Old Maeander" occurred roughly contemporaneously with that of eastern Lade, i.e. c. CE 1000.

It has convincingly been assumed by classicists as well as palaeontologists that the bones shown to Pausanias as those of the giant's son Asterios were actually Miocene fossils of marine animals. These fossils, which are abundant in the Neogene limestone of the western coast of Asia Minor and the adjacent islands, e.g. Samos, may have inspired the Milesian philosopher Anaximandros (c. 635–545 BCE) to develop his theory that the sea once covered what is now dry land, and that life on Earth, including humans, originally stemmed from sea creatures (Aetius *Placita Philosophorum* 5.19.4; Kirk et al., 1994: 153 on no. 133; Mayor, 2000: 73 f. 214 f.; Boardman, 2002: 33–43. 217 no. 159).

4.2.4. Nergiz Tepe

Nergiz Tepe, the "Narcissus Hill", surfaces in the southern Maeander graben some 7 km east of the former Milesian peninsula, which itself forms part of the so-called Nergiz Tepe formation (Miocene freshwater limestone; Schröder et al., 1995: 239) (Fig. 6). Today, the highest point lies 6 m above the surrounding alluvial plain, the level of which is 2 m a.s.l., i.e. about 1 m lower than the plain's average level in this region (Müllenhoff, 2005: 206). Corings have shown that Nergiz Tepe formed an island in ancient times (Müllenhoff, 2005: 158–162). Lohmann (2006: 186 s.v. Dromiskos, 237 s.v. Perne) proposes to identify the hill with the island of Dromiskos, mentioned by Pliny (*Naturalis historia* 2.204) as already landlocked in his time (cf. chapters 1 and 4.3). But this does not fit with the dating for the landlocking of Nergiz Tepe according to Müllenhoff (2005), which Lohmann admits. As yet, the island's ancient name is unknown to us. It still existed around CE 1000, when it was situated in the western part of a gulf which extended from Miletos as far southeast as Herakleia under Latmos, and was named "Milesian Lake" (*Milesie Limne*) or "Gulf of Melamitorum" (*Sinus Melamitorum*) in late Byzantine texts (Herda et al., 2017: chap. 6 Fig. 12).

The island's landlocking occurred during the progradation of the southern branch of the "New" Maeander (today's *Yeni* or *Büyük Menderes*) which bypassed it in the 14th or 15th century CE, thus cutting off the former Gulf of Herakleia/Melamitorum which turned into a brackish interior lake, today's Lake Bafa (Müllenhoff, 2005: 203 Fig. 53; Herda et al., 2017) (cf. Fig. 1). Due to the lower level of the alluvial plain surrounding Nergiz Tepe (Müllenhoff, 2005: 162), the winter floods repeatedly turned the hill into an "island", until the Maeander was regulated in the 1950s.

Fig. 5. The former island of Asteria (Mezar Tepe) seen from the southeast. According to a Milesian myth, here the grave of the giant Asterios, son of Anax, the first founder of Miletos, was situated. The 22 m high hill consists of freshwater limestone. It has been extensively quarried for road construction in recent times. Photo: H. Brückner, 26.09.2015.

4.3. Miletos: from archipelago via peninsula to floodplain

4.3.1. The Milesian peninsula, a former archipelago

Our geoarchaeological studies revealed that the Milesian peninsula as a site of the famous Ionian metropolis developed from an archipelago, settled since at least the 4th millennium BCE (Brückner, 1996, 2003; Brückner et al., 2006, 2014a: 56–64; Müllenhoff et al., 2009). During the time of the maximum Holocene transgression c. 2500 BCE, which equals the Early Bronze Age settlement period Miletos II (cf. Niemeier, 2007), this archipelago consisted of two larger and two smaller islands (Fig. 7). The two smaller islands, supposedly named Dromiskos and Perne, will be dealt with later. The two larger islands lack any ancient name except for 'Miletos'. We call the one to the west 'Athena Temple Island', and the one to the east 'Kale Tepe–Humei Tepe Island'. They were separated from each other by a 150 m broad strait. Their distance to the mainland amounted to only 300–350 m (Figs. 7-8).

The flat, up to 9.60 m a.s.l. high Athena Temple Islands, measuring c. 600 m E–W and 400 m N–S, seems to have been the centre of Minoan Miletos (Miletos III–IV, c. 1900–1450 BCE; cf. Niemeier, 2007: 8–13). It provided a small indented harbour embayment to the north, the 'Athena Harbour' (Brückner et al., 2014a: 92 f.), as well as a large beach harbour in the leeward position to the prevailing northerly winds ("Etesia", "Meltemi") along its eastern and southern coastline.

A local Milesian myth, preserved in a Late Antique *scholium* on the early 2nd century CE geographer Dionysios Periegetes, tells us that the Minoans, arriving under the leadership of name giving Miletos, first settled on the mainland in a place called *Oikous*, "houses", a later suburb of the Greek city of Miletos, before Miletos' son Keladon moved to an island nearby (cf. Herda, 2005: 288 f. 291):

"But Keladon, who ruled over Oikous, buried his father on an island nearby where he himself went to dwell because of an oracle. He called the island 'Miletos'. A dam (*gephyra*) connects today's Oikous with Miletos." (Scholium on Dionysios Periegetes 825).

This story is of special interest as the normal strategy for founding a colony is contrary: for security reasons the newcomers usually first choose an island close by, before they enter the mainland (see chap. 5.1). The story, therefore, likely preserves a historic kernel. The landlocking of the former island of Miletos is a definite historic fact; the "dam" (*gephyra*) may actually be the natural sandbar (*tombolo*) between the mainland and the 'Athena Temple Island', which our corings revealed. This *tombolo* is the result of coastal accumulation caused by longshore currents and adequate sediment supply. It can be dated to the 15th century BCE at the latest, when Miletos became dominated by Mycenaean Greeks (Miletos V–VI, c. 1450–1220 BCE; cf. Brückner et al., 2014a: 57 ff.).

A similar *tombolo* was detected between the 'Kale Tepe–Humei Tepe Island' and the mainland. But it developed much later, during Protogeometric to Geometric times (Miletos VIII a/b, 11th–8th centuries BCE; cf. Brückner et al., 2014a: 64), when the site was settled by Ionian Greeks. In the course of this process, the strait between the Athena Temple Island and the Kale Tepe–Humei Tepe Island was closed and turned into a well-protected embayment. By then the beach harbour on the eastern shore of the Athena Temple Island became part of the 'Theatre Harbour', one of the two closable harbours of Ionian Miletos, where part of her fleet was stationed – the backbone of Milesian colonisation ventures from the 7th century BCE (Brückner et al., 2014a: 64. 69 f. 89 ff.; Brückner et al., 2014b: 775. 782 f.) (Fig. 8). The other closable harbour, the 'Lion Harbour', was located between Kale Tepe and Humei Tepe, forming a 300 m long and 100 m broad indentation in the Kale Tepe–Humei Tepe Island (Brückner et al., 2014a, 2014b).

During the following 350 or so years, the newly developed Milesian peninsula, consisting of two former islands and two connecting *tomboli*, eventually grew together due to continued littoral deposition, as well as human-induced erosion and denudation processes from the adjacent hills to the south, which in turn caused increased siltation. Parallel to this development, the size and structure of the settlement grew. Besides

Fig. 6. Nergiz Tepe, presently surrounded by fields, was an island in the marine gulf (Ikarian/Karian Sea) and even later in the "Milesian Lake" (*Milesie Limne*). Its freshwater limestone is heavily quarried. The present name means "Narcissus Hill", the ancient name is unknown to us. View towards northwest, in the right background the Dilek Dağları (Mykale Mountains). Photo: H. Brückner 26.09.2015.

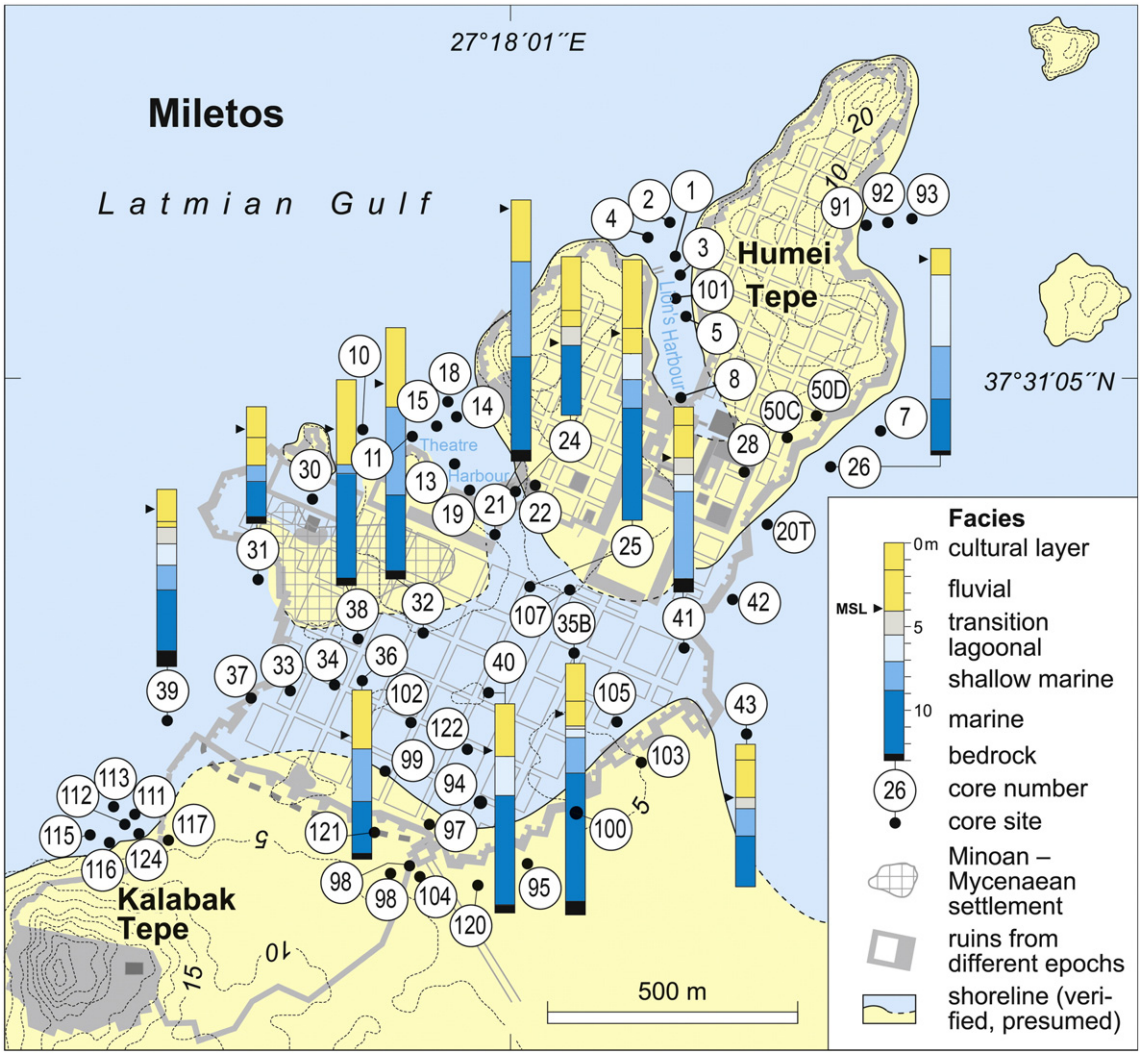

Fig. 7. The Milesian archipelago during the time of the maximum marine transgression c. 2500 BCE. By then it consisted of two larger islands: the so-called 'Athena Temple Island' in the west, where the mythical founder Miletos of Crete was buried, and the extended 'Kale Tepe–Humei Tepe Island' in the centre. East of the latter, two smaller islands were located in antiquity, called Dromiskos and Perne. They were connected to Humei Tepe via sandbars (*tomboli*) in the life time of Pliny (CE 23-79) or even before. Source: Brückner, 2003: Fig. 4 (slightly modified).

the old Bronze Age centre on the former 'Athena Temple Island', *Palaimiletos* ("Old Miletos"), as it was called by the 4th century historian Ephoros (*FGrHist* 70 *F* 127 = Strabo *Geographica* 14.1.6), new districts developed from modest beginnings: first of all around the Lion Harbour, where Apollo 'Delphinios', the "Dolphin", the main god of Iron Age Miletos (Miletos VIII, c. 1050 BCE–CE 400), was said to have landed in mythical times, wherefore his sanctuary, the Delphinion, was located there (Callimachus *Branchos* fr. 229.12–13; cf. Herda, 2005, 2008, 2011: chap. 2.7; Brückner et al., 2014a: 65 ff.).

A new factor in changing the landscape of the Milesian peninsula was systematic artificial infill of formerly swampy areas as a means of urban development since the early 6th century BCE, detected by our corings (Fig. 8). Affected were the major public areas of the southern 'Lion Harbour', the 'North Market' and the Delphinion sanctuary, as well as the eastern 'South Market'. These measures formed part of the implementation of a new orthogonal insula-street grid which optimized the organisation of traffic in between the six harbours of Miletos, the city area, and its countryside. It can be argued quite convincingly that the planners behind were men like the philosophers Thales and his companion Anaximandros, who founded the Milesian school of natural philosophy, the first Greek philosophical school (Herda, 2005, 2013b: 84 ff.).

The landlocking of formerly marine areas of the peninsula continued through Classical, Hellenistic and Roman times, increasing significantly when the northern "Old" Maeander reached the waters north of Miletos around CE 300. The 'Kalabak Tepe Harbour' to the SW was silted up, as was the 'Athena Harbour'. The 'Theatre Harbour' had lost most of its capacity already in Late Classical times, while the 'East Harbour' may simply have moved further to the east. During the time of the geographer Strabo (first half of the 1st century CE), four harbours were still in use, one of them, the 'Lion Harbour' or 'Harbour of Dokimos', functioning as a lockable harbour for a fleet (Strabo *Geographica* 14.1.6; cf. Brückner et al., 2014a: 64 ff., Brückner et al., 2014b: 774 ff.).

4.3.2. Finally connected: Dromiskos and Perne

In close vicinity to Miletos two islands had been situated, which in the lifetime of Pliny (CE 23–79) or even before had become the most recent part of the peninsula. In the already quoted passage (chap. 1), Pliny mentions that

"nature" (*natura*) "has taken islands away from the sea and joined them to the land (...) Dromiscos and Perne to Miletos" (*Naturalis Historia* 2.204; transl. H. Rackham, 1967).

The two islands are not mentioned by name in any other preserved ancient source, so we have to rely on their names as primary

LEGEND

age of buildings

- modern
- Islamic
- Byzantine
- Roman Imperial time
- Classical-Hellenistic
- Archaic
- ambiguous age
- street-insulae-grid (Archaic-Classical)

distribution of land and water area

- land area at maximum transgression (around 2500 BC)
- water area at maximum transgression
- water area during Archaic time
- water area during Roman Imperial time
- coring site
- contour lines

map based on:

Bendt, W. (1968): Topographische Karte von Milet, M 1:2.000 (Milet II, 4); geophysical survey CAU Kiel, Dr. H. Stümpel; own topographical survey

Source: **Marc Müllenhoff, Alexander Herda & Helmut Brückner** (2008): Geoarchaeology in the City of Thales - Deciphering Palaeogeographic changes in the Agora Area of Miletus. Philippika, 1: 97-110; Wiesbaden.

cartography: Marc Müllenhoff, Alexander Herda

Fig. 8. The Milesian peninsula and its harbours in Archaic–Roman times. The position of the shoreline is indicated for three time slices (maximum marine transgression, Archaic time, Roman Imperial time). Source: Brückner et al., 2014a: Fig. 10.

information. The Latin name *Dromiscos*, easily recognisable as Greek *Dromiskos* (Δρομίσκος), is etymologically clear: it is the diminutive of *dromos*, the Greek word for "race", "course", or a "place for running", "race-course" for athletes, horses, or chariots, as well as a "broad, straight street" resp. "avenue" (Liddell et al., 1996: 450 s.v. δρόμος). As a topographical term it can designate a long, small peninsula, like the *Achilleos Dromos* at the mouth of the Borysthenes river in the northern Black Sea. Therefore, it seems likely that *Dromiskos* was originally a small, longish island (Bürchner, 1905a assumed "a narrow tongue of land which was deposited by the Maeander"; Lohmann, 2006: 186 s.v. Dromiskos).

Perne (Πέρνη) is likely a Pre-Greek Anatolian-Luwic place name, related to Hittite *parn-*, *pir-*, "house" (Zgusta, 1984: 485 § 1045 Περνις), which would be a suitable name for a settled island. Zgusta lists a Lycian site named *Pernis* (Περνις), perhaps located in the neighbourhood of Limyra. If the name is originally Greek instead, or was later furnished with a Greek 'folk etymology', it can designate two quite different things: either it is the Ionian dialectal form of *perna* (πέρνα), "ham", or the present participle form of the verb *pernemi* (πέρνημι), "export for sale (slaves)", "sell" (Liddell et al., 1996: 1394 s.v. πέρνα, 1394 f. s.v. πέρνημι). The latter case seems most likely. The participle form *pernas* (περνάς) of the verb *pernemi*, used in the epics as *terminus technicus* for "'exporting' captives to foreign parts 'for sale' as slaves", is attested in Homer (*Iliad* 22.45; cf. Chantraine, 1968–1980: 888 s.v. πέρνημι; Liddell et al., 1996: 1394 f. s.v. πέρνημι), where Priamos bemoans on the walls of Troy that Achilles has "killed or sold (*pernas*) to distant islands" (κτείνων καὶ περνὰς νήσων ἔπι τηλεδαπάων) several of his sons, and is now going to kill Hector, too. Did the Milesians have this famous passage of Homer in mind, when they named the island, or took over the Pre-Greek place name by 'folk-etymologizing' it? Possibly, because it functioned as a place, where slaves were traded in reality. At least the Homeric epics were well known to the Milesians as their performance formed the climax of the Greek-Ionian national festival in the *Panionion*. That Perne could have served as the place of a slave market seems all the more likely when we take into consideration its location as well as that of Dromiskos.

Today, two adjacent small rocks are visible on the Maeander plain, separated from the northeastern flanks of Humei Tepe by the stream of the southern "New" or "Large" Maeander which circles around the former Milesian peninsula since the 14th/15th century CE (Fig. 9; Fig. 7 shows them as part of the Milesian archipelago). Same as the Milesian peninsula, they are built up of freshwater limestone (Nergiz Tepe formation) (Müllenhoff, 2005: 23; Tuttahs, 2007: 357 ff.). The smaller northern one is c. 100 m in diameter and up to 12 m a.s.l., the larger one c. 500 m to the south is c. 150 m in diameter and up to 11 m a.s.l. On the topographical map of Wilski of 1906 they are named *Kütschük* and *Böjük Tschakmaklyk*, equaling *Küçük* and *Büyük Çakmaklık* in modern Turkish, meaning "small" and "large place with flint". Carl Humann, the author of the first accurate map of Miletos of 14.06.1891, i.e., before the German excavations started in 1899, has *Kütschük* and *Böjük Tschakmak-tepe* ("Small" and "Large Flint-Hill") (Weber, 2007: 328 Fig. 1). On *Kütschük Tschakmaklyk* some modern graves are marked (Wilski, 1906: 21, map, quadrant 3E). They are indicated as medieval in the map of (Wulzinger et al., 1935: pl. 48; reprinted in: Weber, 2007: 339–341 Fig. 11, "Friedhof"). Wulzinger et al. (1935: 60) remark that the graveyard is still in use in their time by nomadic Yürüks. According to them the same situation, medieval as well as present Turkish graves, was the case also on *Tschakmak-tepe* (Wulzinger et al. leave out the designation *Böjük*, "large"; this island is not included in their map).

Today, both hillocks, which lack a modern name, are occupied by farm-houses (Fig. 9). The southern, former *Böjük Tschakmaklyk*, is now integrated into the 3.53 m a.s.l. high dam protecting the plain to the north from the winter floods of the "New" resp. "Large" Maeander (Tuttahs, 2007: 446 with course of "Hochwasserdeiche", flood protection dams, in Fig. 479).

It has been overlooked so far that in 1877 Olivier Rayet (1847–1887) in his groundbreaking geoarchaeological reconstruction of the Maeander progradation proposed to identify these two small rocks 300 to 350 m east of Humei Tepe with Dromiskos and Perne (Rayet and Thomas, 1877: 30 f., map pl. 2 "Iles Dromiscos et Perné"). The only scholar who ever recognized the discovery of Rayet was Carl Humann in his map of 1891, which has never been properly published, but only in a small copy (Weber, 2007: 328 Fig. 1; to be read with a magnifying glass: "Ins. Dromiskos?" below "Kütschük Tschakmak-tepe", and "Ins. Perne?" below "Böjük Tschakmak-tepe"). The two islands have been neglected in recent studies. The only exception is Tuttahs (2007: 358 f. Fig. 388). This is partly depending on the task of how to map the large area of ancient Miletos properly. In the first years of excavation reports, the two islands still appear in the maps depending on that of C. Humann of 1891 (see Weber, 2007: 328–331 Figs. 1–4), while they are left out after 1906 (see Weber, 2007: 331–335 Figs. 5–6. 8). They reappear as islands on the maps drawn by Armin von Gerkan (1924–1935) for 2nd century CE Miletos (Weber, 2007: 336–339 Figs. 9–10). After WW II, they are left out once again, first of all in the influential new topographical map by Walter Bendt of 1959–1965 at a scale of 1:2000 (Bendt, 1968).

According to our reconstruction both islands were landlocked between the 1st and 2nd centuries CE, when the Maeander had not yet reached Miletos. Therefore, the reasons for the landlocking are denudation from the mainland, and/or the formation of sandbars (*tomboli*) due to longshore drift in the leeward position of the peninsula. The already discussed results for the Maeander delta progradation (Müllenhoff, 2005) largely confirm this reconstruction (cf. Fig. 1), which nevertheless still has to be demonstrated by corings in the area of the assumed tomboli. That Rayet also gave preference to this scenario becomes evident from his reconstruction of the changes of the eastern shoreline of the Milesian peninsula in three steps: 500 BCE, 1st century CE, end of 2nd century CE (Rayet and Thomas, 1877: 30 f., map pl. 2 "Iles Dromiscos et Perné"; see Herda et al., 2017: chap. 4 Fig. 7).

The landlocking of *Küçük* and *Büyük Çakmaklık*, respectively Dromiskos and Perne, substantially improved the conditions for the 'Humei Tepe Harbour', the facilities of which (warehouses, quay construction etc.) have recently been detected with geophysical methods outside the fortification wall running along the foot of Humei Tepe (Tuttahs, 2007: 356 ff.; Bumke and Tanrıöver, 2012: 76 Fig. 75; Brückner et al., 2014a: 71 Fig. 16, 91 f.). Three geoarchaeological corings in the harbour basin (Mil 91–93) have shown good conditions for landing ships, which lasted until at least early Byzantine times if not longer (Müllenhoff, 2005: 93; Tuttahs, 2007: 358 f. Fig. 388). The presence of a commercial harbour at the eastern flank of Humei Tepe was confirmed in 2011 when H. Bumke, Halle, excavated the harbour gate, and when an inscriptional copy of a letter of the Roman emperor Hadrian dated to CE 131 was discovered, allowing the foundation of a corporation (*oikos*) of Milesian shipowners (*naukleroi*) (Bumke and Tanrıöver, 2012: 78 Fig. 80; Ehrhardt and Günther, 2013; Brückner et al., 2014a: 92).

The historian Arrian of Nicomedia (2nd century CE) mentions a remarkable event taking place during the siege and conquest of Persian-dominated Miletos by Alexander the Great in 334 BCE (Arrian, *Anabasis Alexandrou* 1.19.4–6). The main sources Arrian's account relied on were the works of Alexander's companions Ptolemy and Aristobulus (Strasburger, 1934: 24 f.; Brunt, 1976: XVIII–XXXIV; Bosworth, 1980: 16–34):

"Then, as the Milesians and mercenaries were hard pressed on all sides by the Macedonians, some threw themselves into the sea and inverting their shields paddled over to a little nameless island (*nesida anonymon*) off the city (…). With the city now under control, Alexander sailed in person against those who had fled to the islet, ordering ladders to be brought to the bows of the triremes, so as to disembark from the ships on the cliffs (*apotoma*) of the island as if on a city wall. (…) There were about 300 of these Greek mercenaries." (*Anabasis Alexandrou* 1.19.4–6; transl. Brunt, 1976).

Fig. 9. View from Humei Tepe towards the northeast on two former small islands, presumably Dromiskos and Perne in antiquity. One is visible to the right with houses and trees, the other one in the middle part to the left with a house and a group of trees. Their modern names are Büyük (B) and Küçük (K) Çakmaklık. Between the two, where the Humei Tepe forms an embayment, the 'Humei Tepe Harbour' (HH) was located. Today this area is crossed by the "New" Maeander River which separates the two hillocks from Humei Tepe. Photo: H. Brückner, 26.09.2015.

Von Graeve (2000: 126 f.) identified the small "nameless" (*anonymon*) islet, where 300 mercenaries found shelter, with either *Küçük* or *Büyük Çakmaklık*. Bosworth, in his commentary on Arrian, ingeniously identified Arrian's nameless island with either Pliny's Dromiskos or Perne (Bosworth, 1980: 139).

To sum up: *Küçük* and *Büyük Çakmaklık* both match Arrian's description of the nameless cliffy (*apotoma*) islet. As there were no other two islands at such a close distance to Miletos which could easily be landlocked, *Küçük* and *Büyük Çakmaklık* must be consistent with Pliny's Dromiskos and Perne, though it seems impossible to decide which of the two islands can be precisely attributed to one or the other. Arrian delivers us as *terminus post quem* for the landlocking the end of the 4th century BCE. The *terminus ante quem* is given by Pliny's *Naturalis Historia* (mid-1st century CE).

5. The Küçük Menderes and Ephesos – delta progradation and the demise of Syrie

Since Neogene times, the W–E striking Küçük Menderes graben has formed; it is filled with Miocene to Quaternary deposits (Rojay et al., 2005). The northern mountains are built up by various kinds of marble (dominant), phyllite, carbonaceous schist and paragneiss, while the south and east of the study area as well as large parts of the Küçük Menderes catchment mostly consist of easily erodible, deeply weathered mica schist (Philippson, 1912; Vetters, 1989; Brückner, 1997b; Çakmakoğlu, 2007; Rantitsch and Prochaska, 2011). The ancient city of Ephesos is located at the southern flank of the graben, c. 6 km east of the Aegean Sea. Same as for the Milesia, geoarchaeological research in the Ephesia started in the 1990s (Brückner, 1997b, 2005; Kraft et al., 2000, 2001, 2005, 2007, 2011; Brückner et al., 2008; Stock et al., 2013, 2014, 2015, 2016; Delile et al., 2015).

Due to the continued delta advance of the Küçük Menderes and its tributaries since the 5th millennium BCE, the Ephesian gulf has nearly completely been infilled with fluvial sediments, so that several metres of alluvium overlie the marine strata (Kraft et al., 2000, 2005; Brückner, 2005). Fig. 10 is a synoptic view of the scenario of the delta progradation.

Among others, the former island of Syrie (Kuru Tepe; Figs. 10–11, 13–14) and the two lakes at the northern flank of the graben Gebekirse Gölü and Çatal Göl (Fig. 10; names according to the modern Turkish map, Harita Genel Komutanlığı, 1996; on Schindler's map of 1906: Göbek-Kilisse-Gjöl and Tschakal-Boğhaz-Gjöl) bear witness to the former marine embayment. The Küçük Menderes was meandering until the beginning of the 20th century CE. Due to hydraulic measures the river is today regulated and an irrigation-drainage system is installed in the floodplain (Güldali, 1979). As for the neighbouring Büyük Menderes valley, the valley floor is nowadays used for agricultural purposes. The geomorphological setting of the outer delta plain, into which at least two former islands have been integrated, is clearly visible in Fig. 12.

5.1. Historical accounts and sedimentary evidence

In the already quoted passage of his encyclopaedic "Natural history" (*Naturalis historia* 2.201), Pliny the Elder (CE 23–79) adduces Ephesos as an example for the "increase of the land … by what is brought down the rivers" or "by the receding of the sea". Further on he writes (5.115):

"From these [rivers] comes a quantity of mud which advances the coastline and has now joined the island of Syrie on to the mainland by the flats interposed." (transl. H. Rackham, 1969).

Thus, the siltation of the narrow strait between Syrie and the mainland, which had already occurred during the latter part of the Classical period (Stock et al., 2014: 57), was still present in the collective memory of the Roman era.

To verify the historical accounts and reconstruct the siltation process of the marine embayment, many percussion cores have been retrieved from the modern floodplain. The scenarios for the delta advance (Figs. 10–11) are the result of many years of geoarchaeological research.

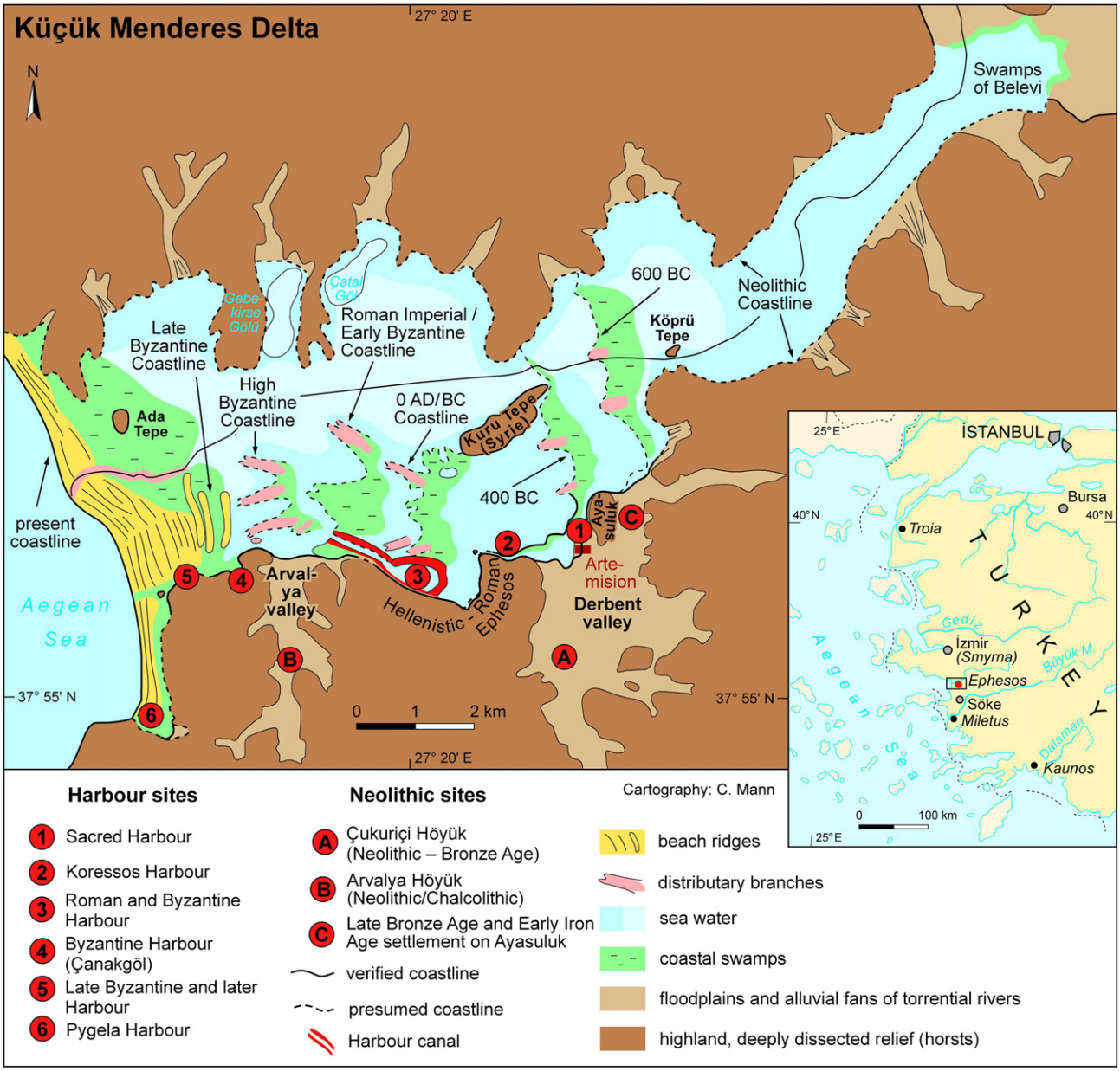

Fig. 10. Scenario of delta progradation for the Küçük Menderes (Kaystros) since the max. transgression 5000-7000 years before present. The former 'Ephesian gulf' hosted several islands; Syrie (now called Kuru Tepe) is the most prominent. The positions of the shoreline are indicated for different time slices. Note the geomorphological change from the bird's foot delta of the inner gulf to a beach ridge – swale dominated coast with a blocked delta when coastal longshore currents became dominant. Due to the continued delta advance the harbour of the settlement had to be relocated several times.
Source: Brückner, 2005, modified.

Among others, a geological transect between Panayırdağ and Kuru Tepe (Syrie) had revealed the stratigraphic architecture of this geoarchive, especially the thickness of the marine facies, while ^{14}C age estimates provided the chronological framework (Brückner, 1997b; see Fig. 11 for location of drill cores). Meanwhile this information has been supplemented by further corings. A typical sediment sequence, representing the subsurface strata of the Menderes floodplain can be demonstrated by drill core Eph 237 close to the former Koressos harbour, the main harbour of the area until Hellenistic times (Figs. 10–11; Steskal, 2014, 331 Figs. 7–8; Stock et al., 2014, 37–38. 51. 55. 57 Fig. 8).

In drill core Eph 237 (Fig. 15), located 200 m to the north of Panayırdağ and the Roman Vedius gymnasium (cf. Fig. 11), the pre-Holocene bedrock was not encountered, due to the steep fault zone bordering the Küçük Menderes graben to the south. Its position is presumably at a depth of 20 or so metres below present mean sea level (b.s.l.). The typical stratigraphy shows slope debris, overlain by transgressive facies (beach deposits with abundant littoral to sublittoral macrofauna) and shallow marine silts. The transgression reached this area during the 6th millennium BCE (cf. Brückner, 1997b).

In Eph 237, the base of the core at 9 m b.s.l. consists of sandy silts (Fig. 15), deposited in a shallow marine environment (foraminifers: *Adelosina* sp., *Ammonia beccarii*, *A. parkinsoniana*, *Elphdium* sp.; ostracods: *Acathocythere* sp., *Ponticythere turbida*, *P.* sp.). Typically brackish species (foraminifer: *Ammonia tepida*; ostracod: *Cyprideis torosa*) are quite common, and it is likely that fluvial input already dominated the area. This interpretation is supported by the high K/Ca ratio.

The marine strata are overlain by coarser deposits, mostly sands of marine to fluvial origin (8.77–2.89 m b.s.l.). The increasing influence

of the Küçük Menderes and its tributaries is apparent in the geochemistry as well as the microfauna (decline of marine species; they are absent from ~5 m b.s.l. upwards). This coarsening upward sequence with the described faunal inventory can be correlated with many other cores from the delta plain. Geoarchaeological research attests to a rapid delta advance, especially since the 1st millennium BCE (Stock, 2015; see also Eisma, 1978; Erinç, 1978; Meriç, 1985; Hess, 1989; Brückner, 2005).

A mollusc shell from the transition unit (2.89–2.52 m b.s.l.) dates to 480–333 cal BCE. This layer represents a lagoonal environment, indicating the final siltation of the area. It confirms the results from the geological transect between Panayırdağ and Kuru Tepe (Syrie) which dated the siltation to Classical and Hellenistic times (details in Brückner, 1997b).

The following light greyish clayey silts (2.52–1.40 m b.s.l.) with low values of electrical conductivity and a lagoonal fauna (mollusc shell: *Cerastoderma glaucum*; foraminifers: *A. tepida*, *Haynesina germanica*; ostradod: *C. torosa*), indicate a freshening of the depositional environment from the 5th century BCE on. By then, the coastline had already bypassed the coring site. The top of the sedimentary column consists of floodplain deposits with abundant evidence of human influence. The ^{14}C–age inversion indicates a reworking of the dated piece of wood.

5.2. Islands of the Küçük Menderes graben

Syrie is definitely the most famous example of a former island in the Ephesian gulf. Nonetheless, there are more island candidates as evidenced by a view on the topographic map: while it is questionable for Köprü Tepe, it is sure for Ada Tepe (Fig. 12) and an unnamed islet east of the modern holiday village of Pamucak (see also Figs. 10–11). These names were adopted from Schindler's (1906) map; their ancient names are unknown to us. Ada Tepe (in Turkish: island hill) is still in an amphibic environment.

In the foundation myth of Ephesos, as related by the historian Kreophylos in his "Annals of the Ephesians", a small offshore island is mentioned. Kreophylos' book, written around 400 BCE, is lost for the most part. In the excerpt quoted by Athenaios (8, 361c–e [62] = *FGrHist* 471 F 1) the name of the island is not given, albeit it is very likely to be identified with Syrie:

"The people who were trying to found Ephesus had a great deal of trouble, because they were unable to locate a site. Finally they sent to the god's oracle and asked where they should put their city, and he prophesied to them that they should found a city in a place a fish would show them and to which a wild boar would lead the way. […] The Ephesians crossed over from the island where they had been living

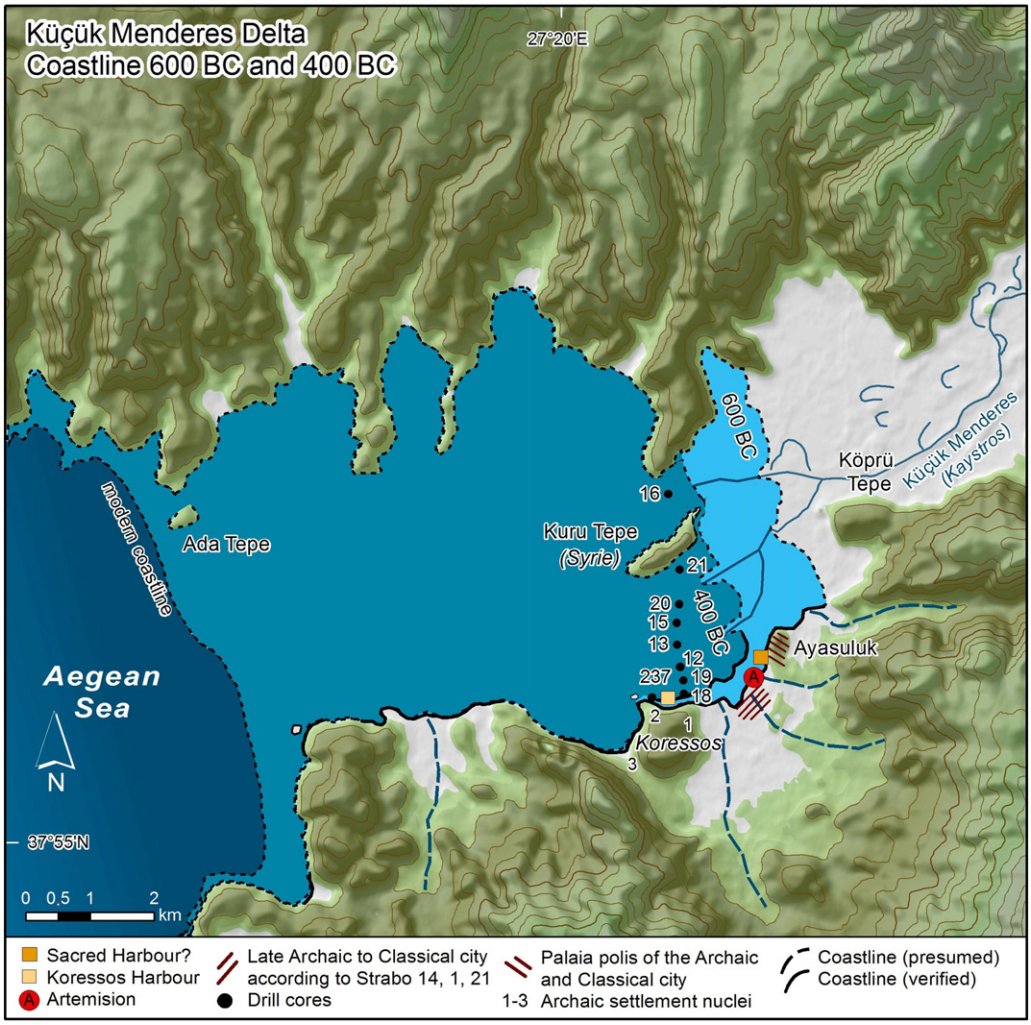

Fig. 11. Scenario of the delta advance ~600 BCE and ~400 BCE. The reconstruction is mainly based on percussion corings. The coring sites of the geological transect from Panayırdağ via Kuru Tepe to Cevasırdağ are indicated (details in Brückner, 1997b). Around 600 BCE, Syrie was still an island. After 400 BCE, Syrie became landlocked due to the progradation of the Küçük Menderes delta. The island was transformed into a peninsula. A few centuries later it was totally integrated into the floodplain of the river. Then the "life cycle" of this estuarine island was completed. Besides Syrie there was at least one more island in the marine gulf (on Schindler's map of 1906 called Ada Tepe). Based on Brückner, 2005 (modified and supplemented).

for 20 years, and settled Trecheia and the area around Coressus for a second time […].” (transl. Olson, 2008).

It is controversially discussed, if this foundation legend contains an authentic nucleus embedded in a mythical narrative (Kerschner, 2006), or if it is in its entirety a later retrospective construction of the past (Bintliff, 2006: 111). A very similar pattern of Greek emigrants – settling first on an offshore island for a short period before founding a permanent settlement on the opposite coast under the guidance of an oracle – appears in the narrative on the foundation of Cyrene in northeastern Libya in the second half of the 7th century BCE. Herodotus (4, 150–158) relates that Theraens settled in a first, unsuccessful attempt on the small island of Plateia off the Libyan coast, before changing to the mainland.

The ancient literary sources suggest that Syrie was located close to the city in the inner part of the now silted-up gulf of Ephesos. In this area, there is only one feature which can be interpreted as a former island: the hill of Kuru Tepe (Figs. 10–11, 13–14). This identification dates back to the 19th century (Guhl, 1843, map; Bürchner, 1905b: 2779–2780; Benndorf, 1906; Schindler, 1906; Honigmann, 1932); it has never been seriously contested. Kuru Tepe is a hill of elongated shape, with two summits of 86 and 89 m a.s.l. and an extension of 1.6 km in its main axis (SW–NE). It is situated at a distance of c. 1.7 km northwest of Ayasuluk hill, where the settlement was located during the Late Bronze Age and Early Iron Age.

The earliest archaeological traces from Kuru Tepe date back to the Archaic period. Scherrer (2007: 330 with n. 47) reports surface finds of Archaic and Classical pottery from an extensive survey in 1997. At the southern tip of the hill there was a *tumulus* with a polygonal grave chamber, and a *dromos* built in ashlar masonry. The latter was unearthed in a rescue excavation by the Efes Müzesi in 1985; it dates to the late 6th/1st half of the 5th century BCE (unpublished, mentioned by Bammer, 1988: 17 Fig. 14; Meriç, 2009: 43; Mohr, 2015: 320). A watchtower, presumably of Hellenistic age, is reported by Meriç (2009: 43).

No archaeological traces of the Early Iron Age have been found on Kuru Tepe – the period when the so-called Ionian Migration is said to have taken place according to the ancient tradition. This ‘argument from silence’, however, cannot be used to contradict the narrative that the Greek migrants settled first on the island of Syrie. On the one hand, no intensive survey nor systematic excavation has yet been carried out on this hill; on the other hand, a temporary settling of the Early Iron Age would have left behind only scarce residues. If this settlement were situated at the shore of that period, it would have been buried meanwhile under several metres of alluvia of the Kaystros river, thus being invisible in a modern survey.

If the narrative of an initial settling on Syrie constitutes an authentic nucleus within the foundation myth, the water supply must have caused a major problem for the Greeks living on the island. Nowadays, no spring exists on the limestone hill, a fact also expressed by the modern Turkish name “Kuru Tepe” meaning “dry hill” (cf. Scherrer, 2007: 30; Meriç, 2009: 43; the name “Korudağ Tepe”, alternatively used on modern maps, meaning “wooded hill”, is not consistent with the contemporary vegetation of macchia; cf. Figs. 13–14). In contrast, D. Crouch (2003: 235) assumed: “Kuru tepe […] lies in the path of this aquifer. It is a horst, part of the natural system for storing water in the valley.” W. Prochaska (pers. comm.), however, considers the existence of springs on Kuru Tepe highly improbable, as the former island was too far away from the mainland to produce sufficient pressure for an artesian spring. The apparent lack of a local water source on the former island leads to the conclusion that it is quite unlikely that people had actually settled there for several years, as stated in the foundation myth according to Kreophylos.

6. Discussion

The Küçük and Büyük Menderes rivers reveal the typical delta advance which can also be observed in other major river systems. Two phases of delta evolution can be distinguished (Anthony et al., 2014):

Fig. 12. An isolated hill, once an island of the former Ephesian gulf. The ancient name is unknown to us. On Schindler's famous map of 1906, the hill is identified as Ada Tepe (AT), “Island Hill”. Meanwhile, it was “captured” by the Küçük Menderes river, which integrated the island into its floodplain. The outer delta plain, in parts still amphibic, shows a distinct ridge-and-swale topography. Note the delayed river mouth due to the strong southbound coastal current, which is typical for a blocked delta. Nowadays the millennia-long delta advance is terminated; over the last few decades a landward shift in the shoreline has taken place, resulting in coastal erosion. This has been caused by ongoing sea-level rise associated with global warming, and limited fluvial sediment supply due to hydraulic measures (irrigation of fields, building of dams). View towards the north. Oblique aerial photograph from a power glider, H. Brückner, 13.09.2011.

Fig. 13. View from Bülbül Dağ looking north on the former island of Syrie (S), now called Kuru Tepe. Clearly visible are prominent buildings and streets of the Roman city of Ephesos, such as the straight street Arkadiane which connected the theatre with the Roman harbour (to the left, partly filled with water). A Artemision near the modern city of Selçuk; AH Ayasuluk Hill with the medieval castle; KT Köprü Tepe; ÇG Çatal Göl, a remnant of the former marine embayment. Oblique aerial photograph from a power glider, H. Brückner, 13.09.2011.

With the sea level stagnation from Mid-Holocene times on (Stanley and Warne, 1994; Kayan, 1999), the river systems around the Mediterranean Sea slowly started to prograde their deltas. Since the Bronze age, especially during the last 2500 years, scientists have proven a faster delta advance, often along with a stronger human impact (deforestation and subsequent erosion), and thus a larger sediment supply (see e.g. Arnaud-Fassetta, 2002; Zolitschka et al., 2003; Bellotti et al., 2011; Maselli and Trincardi, 2013). E.g., the Rhône (Vella et al., 2005), Po (Machetti, 2002), Tiber (Bellotti et al., 2011) and Ebro (Palanques and Guillén, 1998) built out their deltas, strongly impacted by human influence.

Other than Grove and Rackham (2001) who strongly emphasized the climatic influence, most of the researchers attribute the landscape changes in the Mediterranean to human impact, in many cases even since Neolithic times. This is evident from a compilation by Brückner (1986) and has been confirmed by several other authors in more regional studies, for examples lately by Psomiadis et al. (2013) in the Thessaloniki plain (Greece).

Fig. 14. View from Ayasuluk hill on Kuru Tepe, the former island of Syrie (in the centre of the background). To the left in the foreground a tower of the medieval fortification on Ayasuluk hill. Photo: M. Kerschner, 30.08.2012.

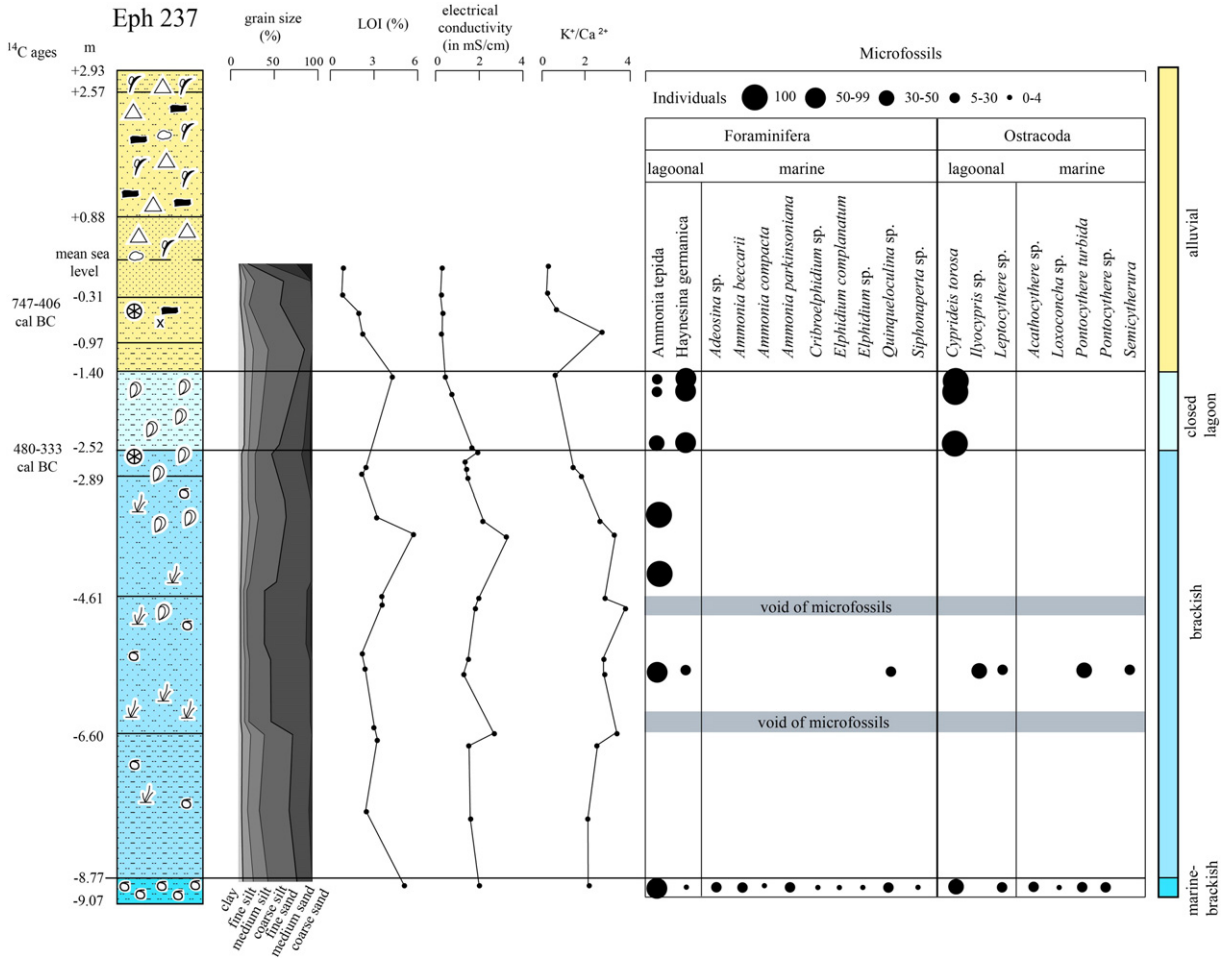

Fig. 15. Percussion core Eph 237 with sedimentological, geochemical and microfaunal data, as well as the interpretation of the sedimentary environment. For the location of the drill core see Fig. 11. Source: new data.

Human impact may also have the effect of a delta retreat. The Nile delta shows an advance until 4000 BP, followed by a decline of sediment supply due to drainage of the different river channels (Marriner et al., 2012). Since several decades, most of the deltas worldwide suffer from erosion due to a deficit in sediment supply and the ongoing sea-level rise, wherefore the Küçük Menderes delta is a typical example (cf. Fig. 12 with its caption).

7. Conclusion

The early Holocene sea-level rise created many marine gulfs. Where the sea transgressed into river mouths, ria-type coasts evolved. Formerly dry land drowned and, depending on a favourable topographic setting, islands were born ("estuarine islands"). When the sea-level rise decelerated seven millennia ago, the rivers started to build out their deltas and infill the embayments. Thus, many of these estuarine islands became landlocked, were transformed into peninsulas and finally integrated into the floodplain. To describe this geo-metamorphosis we coin the term: "life cycle of an island".

This article demonstrates many examples for these profound landscape changes from western Anatolia. It focuses on the identification and the fate of former islands and demonstrates the added value generated by interpreting ancient sources in a synoptic view that links ancient history and archaeology with geosciences.

Our long-term geoarchaeological research of the Büyük and Küçük Menderes grabens has proven the landlocking of former estuarine islands. The most prominent of them are Hybanda, Lade, Asteria and Nergiz Tepe in the Büyük Menderes (Maiandros, Maeander) graben, and Syrie in the Küçük Menderes (Kaystros) graben. Even the famous Milesian peninsula evolved from an archipelago; it started with two main islands that were later complemented by two smaller ones, which we identify as the islets Dromiskos and Perne. Even today, several residual lakes attest to their former marine past: Lake Bafa and Lake Azap are remnants of the Ikarian/Karian gulf, and Gebekirse Gölü and Çatal Göl of the Ephesian gulf.

Since mid-Holocene times, the Büyük and Küçük Menderes rivers have prograded their deltas and silted up these marine embayments, despite the continued rise in sea level and occasional co-seismic subsidence of the grabens. One of the main factors for the increased siltation since Roman times was deforestation as a trigger for erosion processes in the drainage basins; this resulted in a high sediment load and in accelerated delta advance. In principal, these erosion/accumulation processes were already understood in ancient times, as demonstrated by statements of the historian Thucydides (5th century BCE), the geographer Strabo (1st century BCE – early 1st century CE), the natural historian Pliny (1st century CE), and the travel writer Pausanias (2nd century CE).

Our research results demonstrate the importance of the interplay between social sciences on the one hand and natural sciences on the other. Historical records should therefore be used more intensively, and, wherever possible, be verified by geological records.

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