



First stratigraphic evidence and absolute dating of a Bronze Age settlement in the Bakırçay valley in western Turkey

Steffen Schneider ^{a,*}, Marlen Schlöffel ^a, Christoph Schwall ^b, Barbara Horejs ^b, Brigitta Schütt ^{c,d}

^a Osnabrück University, Institute of Geography, Seminarstraße 19 ab, 49074 Osnabrück, Germany

^b Institute for Oriental and European Archaeology (OREA), Austrian Academy of Sciences (AAS), Hollandstraße 11–13, 1020 Vienna, Austria

^c Freie Universität Berlin, Physical Geography, Malteserstr. 74–100, 12249 Berlin, Germany

^d Excellence Cluster TOPOI, Research Area A – Spatial Environment and Conceptual Design, Hittorfstraße 18, 14195 Berlin, Germany

ARTICLE INFO

Article history:

Received 11 November 2016

Received in revised form 6 February 2017

Accepted 11 February 2017

Available online 16 February 2017

Keywords:

Aegean archaeology

Prehistory

Late Chalcolithic

Early Bronze Age

Geoarchaeology

Bakırçay

ABSTRACT

This paper presents results of the first investigation and the absolute dating of stratigraphic sequences of a pre-historic settlement site in the Bakırçay valley, Western Turkey. The geomorphological and stratigraphical investigations focus on the settlement at the Yeni Yeldeğirmenitepe, a small volcanic hill within the Bakırçay flood plain. So far, this unexcavated site has been relatively dated to the Late Chalcolithic (end of the fourth millennium BCE) and the Early Bronze Age 1 (first centuries of the third millennium BCE) period based on comparisons of surface finds with those from other excavated sites along the Aegean coast of Western Anatolia. Two drilling cores were analysed for their sedimentological and archaeological features, and a chronological model based on AMS radiocarbon dating was developed. Our results show that the settlement was constructed within a dynamic fluvial environment and was occasionally flooded. Its N–S extent was at least 40 m and the thickness of the archaeological layers is up to 2.8 m. The chronological model confirms a first occupation phase or phase of human presence at Yeni Yeldeğirmenitepe dating to the end of the fourth millennium BCE. The main settlement phase dates to approximately the 27th to 24th centuries BCE and is therefore some hundred years younger than previously expected. This new information on the age of the site generates new stimuli for the discussion of the position of the Bakırçay valley within the cultural and economic networks of the Early Bronze Age period in the Aegean region.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

The Bakırçay valley (ancient Kaikos valley) is one of the biggest graben landscapes along the eastern Aegean coast. The oldest known settlements are dating back to the prehistoric period. The question regarding the exact chronological classification of these settlements remains unclear. Therefore, in 2008, renewed archaeological surveys in this area started in the course of the European Research Council Project Prehistoric Anatolia, accompanied by geoarchaeological investigations within the scope of the Cluster of Excellence 'Topoi'. These projects focused on systematic investigations on the already known sites, as well as the search for new evidence. These studies are mandatory to draw a picture of the prehistory in the Bakırçay valley and to reveal possible regional and supra-regional connections. Moreover, the results allow us to evaluate and compare the importance and function of the Bakırçay

valley in the prehistoric landscape of Western Anatolia. At present, >20 prehistoric sites are documented in the Bakırçay valley, which are supposed to cover the time of the Neolithic, Chalcolithic and Bronze Age period (Horejs, 2010a; Horejs et al., 2015). In particular, the detailed studies in the Bakırçay valley offer the possibility to analyse settlement patterns and connectivity of Early Bronze Age sites. The most intensively investigated location is a settlement on the small volcanic hill 'Yeni Yeldeğirmenitepe' in the central Bakırçay flood plain. Owing to a lack of stratigraphic sequences with stratified find assemblages, the only possible way to date the settlement is by comparing the collected artefacts with findings from other sites in the Western Anatolian coastal region. The results of the archaeological analyses of the finds suggest a primary dating to the beginning of the Early Bronze Age period covering the first centuries of the third millennium BCE. However, the finds suggest also an even earlier chronological position at the end of the fourth millennium BCE. Therefore, a habitation of the site Yeni Yeldeğirmenitepe starting at the end of the previous Late Chalcolithic and the Early Bronze Age period has to be assumed (Horejs, 2010a, 2011a). In this study first stratigraphic sequences and radiocarbon dates provided by drilling cores will be presented for the settlement Yeni Yeldeğirmenitepe and the entire region of the Bakırçay valley.

* Corresponding author.

E-mail addresses: schneider@nihk.de (S. Schneider), marlen.schloeffel@uni-osnabrueck.de (M. Schlöffel), christoph.schwall@oeaw.ac.at (C. Schwall), barbara.horejs@oeaw.ac.at (B. Horejs), brigitta.schuett@fu-berlin.de (B. Schütt).

2. Context of the settlement at Yeni Yeldeğirmentepe

Geotectonically, the Yeni Yeldeğirmentepe is located within the Bergama Graben, which is part of the Aegean Extensional Province (Dilek, 2006). Physio-geographically, the area is a subsection of the Aegean Coastal Subregion (Erol, 1983) and has a Mediterranean climate with mild, humid winters and hot, dry summers (Lionello et al., 2006). The region's natural soil cover is formed by alluvial and colluvial soils on the valley floor, and rendzinas and brown forest soils in the mountains and on the sporadic isolated volcanic hills (Erlat, 2007). The soils have undergone degradation due to agricultural use during the past millennia and most of the valley floor is used as cropland. Maquis communities are characteristic for the isolated hills and the valley edges, and mixed pine and oak forests occur in the mountains (Erlat, 2007; Kesgin and Nurlu, 2008). The region's main stream is the Bakırçay. Its watershed is approximately 2900 km² and has, where not straightened and regulated, a channel pattern that transitions from braided to meandering (Aksu et al., 1987).

The Yeni Yeldeğirmentepe is one of the smallest among all the isolated volcanic hills in the Bakırçay valley (Fig. 1b, c). It has an elongated shape and measures c. 100 m from east to west and c. 60 m from north to south. Its highest point rises c. 15 m above the level of the valley floor and c. 25 m above sea level.

The Yeni Yeldeğirmentepe has been the focus of archaeological research since the early 20th century. The first surveys and excavations were conducted by Dörpfeld (1908), Bittel (1950), and Driehaus (1957). The investigations at Yeni Yeldeğirmentepe as well as the Bakırçay valley were resumed in course of intensive survey investigations by Horejs since 2008 (Horejs, 2009, 2010a, 2010b, 2011a, 2011b, 2012a, 2012b, 2013, 2014a, 2014b, 2014c; Pirson and Horejs, 2014; Horejs et al., 2015; Horejs and Weninger, 2016). Intensive agricultural use has affected the state of preservation. Nevertheless, the site is securely identified as a prehistoric settlement by carved stones, remains of architecture represented by stone socle walls and cultural layers clearly visible in profiles (Horejs, 2010a). Finds like ceramic sherds, grinding stones, mortars, pounders and spindle whorls suggest the presence of various domestic activities (Horejs, 2009, 2010a). A comparison of the ceramics found at Yeni Yeldeğirmentepe with those found at excavated sites along the Aegean coast of Western Anatolia lead to a relative dating of the settlement Yeni Yeldeğirmentepe to the end of the Late Chalcolithic and the first centuries of the Early Bronze Age period. Similar findings dating to the Early Bronze Age 1 were found at Troy I (Blegen et al., 1950; Podzuweit, 1979), at Thermy on Lesbos (Lamb, 1936), at Beycesultan XIX–XVII (Lloyd and Mellart, 1962) and at Çukuriçi Höyük IV–III (Horejs, 2011a; Horejs et al., 2011).

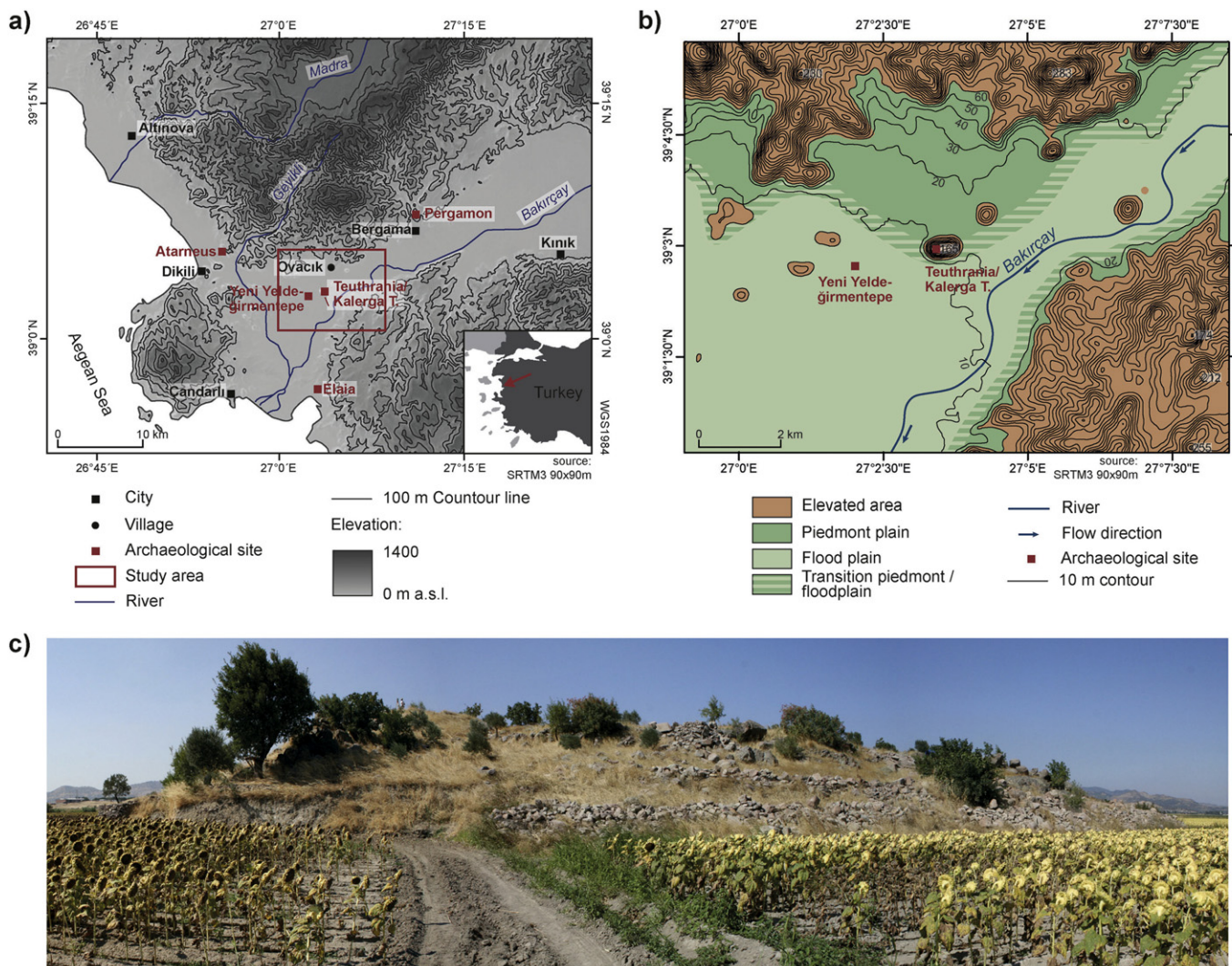


Fig. 1. Study area overview. (a) Topography and archaeological sites of the Bakırçay valley. (b) Main geomorphological elements of the study area. (c) View from the south on the Yeni Yeldeğirmentepe.

Investigations on the environmental context of the settlement at Yeni Yeldeğirmenitepe or the prehistoric settlements in the Bakırçay valley have not been carried out yet. Geoarchaeological studies have focussed on the ancient polis Atarneus on the north-western edge of the valley (Schneider et al., 2013, 2014), on the archaeological site Teut114 (Schneider et al., 2015) and on Elaia, the harbour city of ancient Pergamon, southeast of the Bakırçay delta (Seeliger et al., 2014; Pint et al., 2015).

3. Methods

The fluvial plain surrounding the Yeni Yeldeğirmenitepe was stratigraphically investigated by means of vibracoring. Overall, ten drillings were conducted. Two of these cores, YYT15 (30° 2' 48.2" N, 27° 2' 0.9" E) and YYT45 (39° 2' 46.3" N, 27° 2' 3.4" E), will be discussed in this paper. Drilling YYT15 was conducted with an open tube and sampled in the field. Profile YYT45 was drilled with closed plastic tubes and sampled in the laboratory. The grain size composition was described following the guidelines of the German manual of soil mapping (Ad-Hoc-AG Boden, 2005). The colour of sediments and archaeological layers was determined using the Munsell soil colour chart. 59 samples from the cores were immersed in a 0.01 M potassium chloride solution to determine the pH values and in ultrapure water to determine electrical conductivity (EC, $\mu\text{S} \cdot \text{cm}^{-1}$). The samples were measured using a handheld pH/EC reader (Hanna instruments). The soil-solution ratio was 1:2.5. The total carbon content (TC, mass-%) and total inorganic carbon content (TIC, mass-%) of 19 samples were measured using a Wösthoff Carmograph C-16. TC was determined using dry combustion at 1000 °C in an oxygen atmosphere and subsequent quantification of the evolved CO₂ in 20 ml of a 0.05 M NaOH solution through conductivity (Blättermann et al., 2012). TIC was analysed using an acid sample treatment (H₃PO₄) and conductometrically detected CO₂ flow (Blättermann et al., 2012). The total organic carbon was calculated by subtracting TIC from TC. The loss-on-ignition (LOI mass-%) of 60 samples was measured as described by Dean (1974). After oven-drying the sediment to a constant weight (12 h at 105 °C), the samples were heated to 550 °C and 880 °C for at least 4 h in a muffle furnace. To calibrate the LOI values the carbon content as measured with the Wösthoff Carmograph C-16 were applied (Sutherland, 1998). The magnetic susceptibility of Profile YYT45 was measured using the Bartington Instruments MS2C system at 4-cm intervals on closed plastic tubes. Seven samples of charcoal, one sample of decomposed plant material, and two samples of organic sediment were prepared for AMS dating (¹⁴C) and measured at the Poznań Radiocarbon Laboratory. The AMS dates were calibrated using OxCal 4.2.3 (Ramsey, 2009) and the IntCal 13 calibration curve (Reimer et al., 2013).

4. Results

Drilling core YYT15 was retrieved from the alluvial plain west of the Yeni Yeldeğirmenitepe, in a distance of c. 15 m to the foot of the geological mound. Drilling was stopped at 4.8 m below the surface because an impenetrable stone layer, possibly the bedrock, was reached. Two stratigraphic units are discriminable within core YYT15 (Fig. 2). Underlying Unit 1 (4.8–1.9 m depth) consists of brownish loam clay with interspersed indeterminate debris of molluscs, pieces of charcoal, and precipitations of iron and manganese. The total organic carbon contents vary between c. 0.3 and 0.6 mass-% and total inorganic carbon contents range between c. 0.5 and 1.2 mass-%. At a depth of 4.4 m, a grey sherd of c. 2 * 2.5 cm² with angular edges was found. Three sand layers are intercalated in Unit 1 at 3.0–2.9, 2.8–2.5, and 2.03–2.01 m depth. The sand layers are well sorted with the total organic carbon and inorganic carbon contents below 0.5 mass-%. The sand layer at 2.03–2.01 m depth includes clasts, being well rounded and having diameters up to 0.3 cm. This same layer contains an individual of *Melanopsis praemorsa*.

In Unit 2 of core YYT15 (1.9–0 m depth), layers of loam clay alternate with sand layers. The texture is partly chaotic and the layers have a high content, up to >75 vol%, of angular clasts up to 4 cm in diameter. At 1.5–1.0 m depth, several individuals of *M. praemorsa* and unidentifiable plant remains were found. The electric conductivity fluctuates layer independently between c. 150 and 450 $\mu\text{S} \cdot \text{cm}^{-1}$ throughout the two units of Profile YYT15. The curve does not correlate either with the total inorganic carbon contents (Pearson product-moment correlation coefficient $r < 0.0$, $n = 26$) or with the total organic carbon contents ($r = 0.2$, $n = 26$). pH values of the complete Profile YYT15 are on a constant level within the slightly to moderately alkaline range.

The chronological model of core YYT15 is based on five AMS radiocarbon datings from small, indeterminate pieces of charcoal (Fig. 3). The radiocarbon datings were calibrated with OxCal 4.2.3 and the IntCal13 calibration curve. To confine the overlapping datings and to make use of the knowledge that the underlying deposits must be older than the overlying deposits, the OxCal Poisson-process deposition model (P_Sequence function) was applied (Ramsey, 2008). As the exact deposition rate was unavailable and a uniform deposition rate can be excluded, a variable Poisson parameter value was used (Poisson parameter $k_0 = 1 \cdot \text{depth}^{-1}$; interpolation rate = $0.2 \cdot \text{depth}^{-1}$; $\log_{10}(k/k_0) = 2$; unit = cm) (Ramsey and Lee, 2013). According to the model, the c. 4.6 and 2 m depth range contained four ages ranging from the 34th century BCE to the 25th century BCE. The age derived from the first metre below the surface is almost identical to the fifth metre below the surface and must be considered an outlier (Fig. 3). Thus, it was excluded from the model.

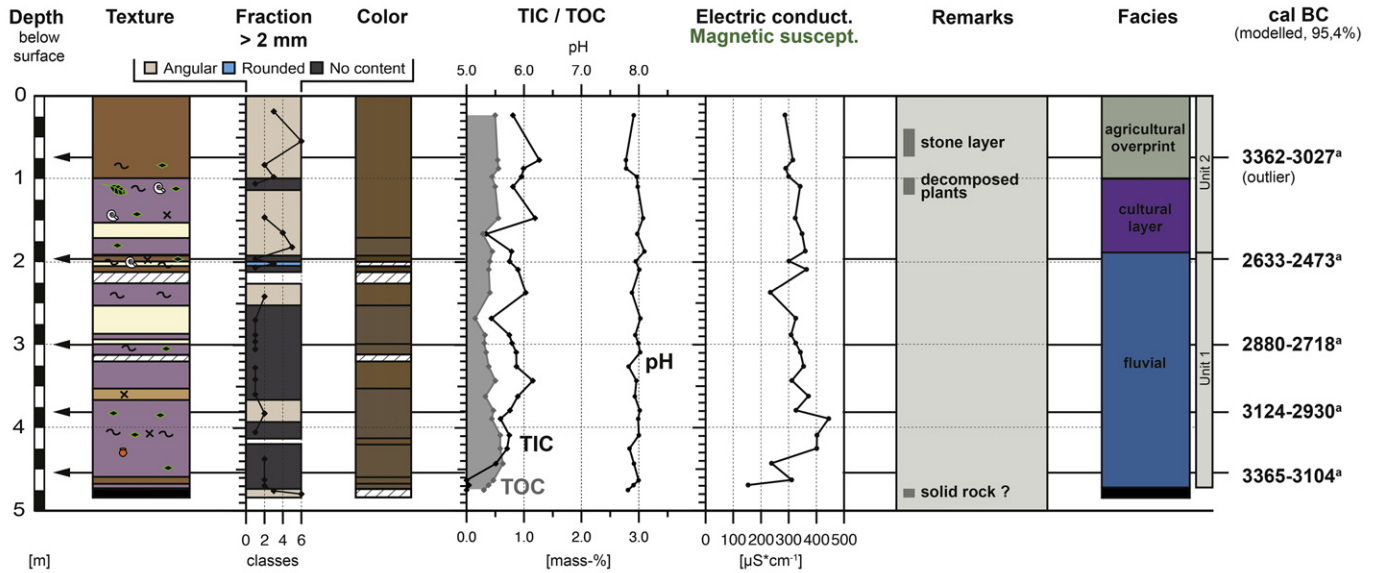
The second core, YYT45, was recovered from c. 40 m south of the geological hill of Yeni Yeldeğirmenitepe. The profile is divided into two stratigraphic units (Fig. 2). Underlying Unit 1 (6–2.8 m depth) consists of very dark brown to dark greyish brown loam clay. It is clast-free, unstratified with its total organic carbon contents ranging between c. 0.5 and 1 mass-% and total inorganic carbon contents averaging 0.9 mass-%. A clast-free layer of coarse sand is intercalated at 5.8–5.7 m depth. A remarkably different layer is intercalated between 4.8 and 4.6 m depth. It has a chaotic, silty to sandy texture and includes clasts up to 3 cm in diameter. Furthermore, it contains intensely weathered components of fine grain size and the yellow-orange colour of burned clay. At a depth of 4.3 m, a ceramic fragment of c. 3 * 2.5 * 1 cm³ was found. At the top of Unit 1 (3.0–2.8 m depth), decomposed, unidentifiable plant remains with greasy consistency, and an individual of *Unio* sp. and three ceramic fragments of c. 1 * 1 * 1 cm³ size were found.

Comparable to Profile YYT15, the pH values of the complete Profile YYT45 are constant within the slightly to moderately alkaline range. The electric conductivity values range layer independently between c. 150 and 500 $\mu\text{S} \cdot \text{cm}^{-1}$.

Unit 2 (2.8–0 m depth) has a completely different appearance compared to Unit 1. The texture is chaotic and is characterized by erratic variations in grain size, colour, total inorganic carbon contents, and magnetic susceptibility. The most prominent feature of this unit is the abundance of ceramics, pieces of burned clay, and charcoal. Fourteen sharp-edged ceramic fragments between 5 * 3.5 * 1 cm³ and 1 * 0.5 * 0.5 cm³ in size are distributed in Unit 2, within a depth of 2.8 and 1.2 m. An individual of *M. praemorsa* occurs at a depth of 1.85 m.

Two AMS radiocarbon datings from dispersed organic sediment, one from decomposed plant material and another from unidentifiable pieces of charred wood are integrated into the chronological model of profile YYT45 (Fig. 3). Owing to differences in the dated material, the reliability of these ages cannot be compared. The dispersed organics, which help date the fifth and sixth metres below the surface, have to be interpreted carefully. This is because their age could reflect the time the organics were formed rather than the time the organics were deposited as sediment. Of course, also the dates from the decomposed plants and the charcoal might overestimate the time of the fluvial sedimentation. With the potential risk of overestimation in mind, we applied the OxCal Poisson-process deposition model (P_Sequence) using

YYT15



YYT45

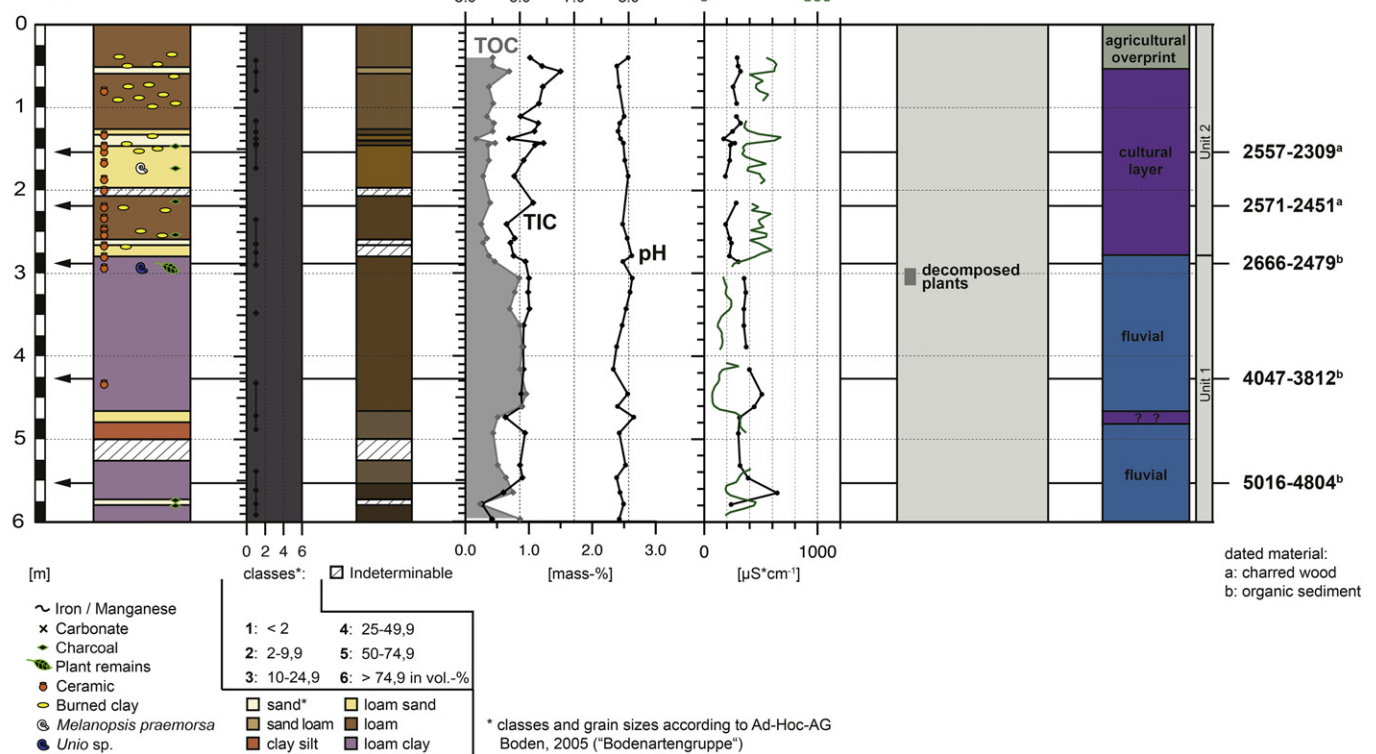


Fig. 2. Stratigraphical features and modelled radiocarbon dates of drilling cores YYT15 and YYT45.

the same variable Poisson parameter as for profile YYT15, again with the aim of confining the overlapping datings. At a depth of 3.0 m below surface, just underneath the lowermost ceramic of Unit 1, and where the significant stratigraphic change between Units 1 and 2 occurs, an additional boundary was introduced into the model. The modelled ages cluster in two phases. The dates from the sixth and fifth metres below the surface fall in the period between the end of the sixth millennium BCE and the middle of the fourth millennium BCE. The ages from the third and second metre below surfaces range between the beginning and the end of the third millennium BCE.

5. Discussion

An analysis of the stratigraphic features of the two drilling cores taken from the environs of the prehistoric settlement Yeni Yeldegirmen-tepe allows a preliminary discussion of the age, extent, and paleogeographical situation of the site.

The chemical and physical characters of the sediments are influenced by the seasonally fluctuating groundwater level. Stratigraphication-discordant precipitations of iron, manganese and carbonate accompanied by layer independent fluctuations of electric conductivity point to a

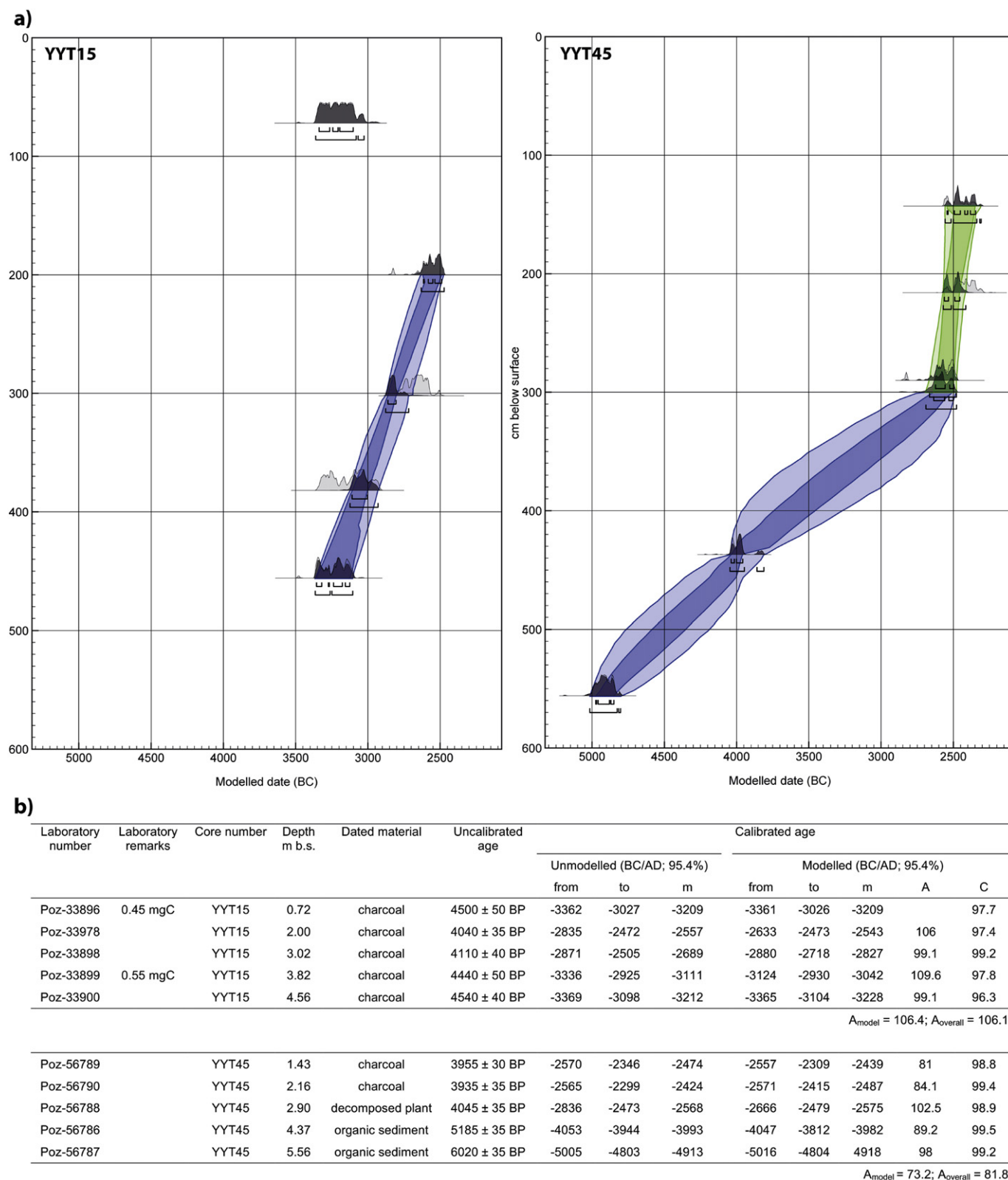


Fig. 3. (a) Age-depth plot of the deposition models of drilling cores YYT15 and YYT45. The models were calculated with the OxCal Poisson-process deposition model (P_Sequence function) with a variable Poisson parameter value (Poisson parameter $k_0 = 1 \cdot \text{depth}^{-1}$; interpolation rate = $0.2 \cdot \text{depth}^{-1}$; $\log_{10}(k/k_0) = 2$; unit = cm). (b) Information on dated material, uncalibrated, calibrated and modelled age.

postsedimentary alteration of the deposits. Compared to other localities in the Bakırçay valley, for example in the north-western region near the city of Dikili, where initial calcretes with a pseudomycel-like

macrostructure and orange-yellow mottled layers have developed (Schneider et al., 2014), the groundwater influence is moderate and only subtly masks the primary sedimentary features. Due to

outcropping lime stone in the watershed of the Bakırçay and the generally calcareous sediment load of the rivers, pH values are on a constant level around 8 within the slightly to moderately alkaline range.

The underlying stratigraphic units of both cores (Unit 1) have a clearly fluvial character. They show an alternation between silty, organic overbank sediments and intercalated sandy layers representing channel deposits. This is a typical succession of facies in the Bakırçay valley and was previously described by Schneider et al. (2014, 2015). Not only texture and grain sizes of the fluvial units of drillings YTT15 and YTT45 are comparable to those presented by Schneider et al. (2014, 2015), but also total organic and inorganic carbon contents as well as electric conductivity and pH values. The fluvial origin of the sediments is underlined by the occurrence of the gastropod *M. praemorsa*, an aquatic snail (Mouahid et al., 1996; Glaubrecht, 1993) and the freshwater bivalve *Unio* sp., which typically inhabits flowing water bodies (Bauer and Wächtler, 2001). The fine-grained overbank sediments were probably deposited during the high flood stages of the Bakırçay and its tributaries, most likely during the time of maximum runoff in winter and spring. The implications of the channel sediments – besides the simple fact that watercourses with channels existed – is hard to discuss on the basis of two drilling cores only, and it is difficult to draw conclusions on channel depth and runoff regime. However, the maximum thickness of the sand layers of c. 3 dm points to smaller watercourses than to watercourses the size of the present day canalized Bakırçay. The fact that the snail *M. praemorsa* typically lives in perennial watercourses supports the hypothesis of the existence of a permanent flow of water.

The only sign of settlement activities in the underlying fluvial Unit 1 of the two cores are two single, isolated sherds at 4.4 m depth in core YTT15 and 4.3 m depth in core YTT45. We cannot exclude that these two sherds are relicts of a perturbation caused by the drilling process. However, we think the occurrence of the artefacts in an almost identical depth below the surface in both cores is a strong indicator of an early anthropogenic or even settlement activity at Yeni Yeldeğirmentepe. Furthermore, the layer between 4.8 and 4.6 m below the surface in core YTT45, 0.3 m below the sherd, might be a cultural layer connected to this early phase of settlement or occasional use. The chaotic texture, the occurrence of clasts, and the evidence of burned clay have a remarkable accordance with the appearance of cultural layers. However, the strong weathering of the layer hinders a clear interpretation and it is therefore uncertain whether this layer really gives evidence of settlement activities at Yeni Yeldeğirmentepe.

The chronological model (Fig. 3) of core YTT15 shows that the fluvial Unit 1 was deposited between c. 3365–3104 cal BCE (4.5 m below surface) and 2633–2473 cal BCE (1.9 m below surface). According to the model, the layer in which the sherd is embedded can be dated to the last centuries of the fourth millennium BCE.

Pursuant to the chronological model of core YTT45, the fluvial Unit 1 was deposited between the beginning of the fifth millennium BCE and 2666–2479 cal BCE. The age of the sediments between five and six metres below the surface point to the beginning of the fifth millennium BCE and to around 4000 BCE. But, as explained above, these ages have to be regarded carefully because they derive from possibly reworked material and might overestimate the actual time of deposition.

However, the date at a depth of 2.8 m is more reliable and it is a most remarkable circumstance that the end of deposition of Unit 1 in core YTT45 differs by about 33 years from the end of deposition of Unit 1 in core YTT15. The difference between the unmodelled dates is only one year (2836–2473 cal BCE vs. 2835–2472 cal BCE). According to YTT45's chronological model, the sherd and the possible cultural layer below date to the last centuries of the fourth millennium BCE and are therefore some hundred years older than the sherd in YTT15. Considering that the chronological model of YTT45 possibly overestimates the age of the layers, the sherd and the possible cultural layer might even be from the same period as the sherd in YTT15: the second half of the fourth millennium BCE. This fits to the supposed beginning of settlement activity at

the Yeni Yeldeğirmentepe in the Late Chalcolithic period, based on surface material studies (Horejs, 2009, 2010a).

In both drilling cores, the overlying stratigraphic Unit 2 differs significantly from the underlying fluvial Unit 1. In core YTT15, Unit 2 is built up of stone layers with non-fluvial transported angular clasts and sandy layers representing channel deposits. Because of the lack of ceramics or any other kind of direct anthropogenic indicator, it is not clear if the stone layers are the result of any settlement activities. They could have been naturally deposited, or been part of stone architecture—for example, walls of buildings. However, it is clear that slope deposition, anthropogenically induced deposition or building measures were repeatedly interrupted by fluvial events.

In core YTT45, the overlying Unit 2 shows clearer signs of anthropogenic influence. The abundance of ceramics, the high amount of charcoal and burned clay as well as the partly stratified texture securely identify the unit as in situ settlement layers. It also proves that the extent of the settlement at Yeni Yeldeğirmentepe, which was so far only known from surface discoveries, reached at least as far south of the geological mound as the position of drilling YTT45 and as deep as 2.8 m below the modern surface level. However, within the settlement layers, sandy fluvial deposits with individuals of *M. praemorsa* and *Unio* sp. are intercalated and give evidence of occasional flood episodes.

The chronological model of YTT15 does not contain information about the period of development of Unit 2 since the only date at a depth of 0.7 m depth is an outlier, which had to be excluded from the model. However, it is clear that Unit 2 developed after 2633–2473 cal BCE, the approximate end of deposition of Unit 1. For core YTT45, the chronological model concludes that the cultural layers between 3 and 1.2 m below the surface were deposited in a relatively short period between the 27th and 24th century BCE, or even almost simultaneously, as the three modelled ages have a significant overlap.

6. Conclusions

This study provides for the first time stratigraphic data and an absolute chronology of a prehistoric settlement in the Bakırçay Valley in western Turkey. The focus is set on the archaeological site upon the small volcanic mound Yeni Yeldeğirmentepe. The settlement has previously been identified by archaeological surface surveys and comparison with similar find assemblages of sites in Western Anatolia and on the East Aegean islands dating to end of the Late Chalcolithic and the Early Bronze Age 1 period (late fourth and the first centuries of the third millennium BCE; cf. Horejs, 2010a).

Our stratigraphic analyses show that the settlement stretches at least 40 m from north to south, and that the archaeological layers stretching to the geological formation of Yeni Yeldeğirmentepe reach up to 2.8 m below the modern surface. The settlement was constructed on fluvial sediments within a dynamic fluvial environment. Some possibly perennial watercourses could be identified in coexistence with the settlement. This might be an indication of the reason why this place was chosen for a settlement. Fluvial layers intercalated within the archaeological layers give evidence of occasional flooding of the site and raise the question whether the settlement was continually inhabited or might have been only seasonally visited during the drier summer months.

The chronological model reveals two phases of settlement activity, or at least of human usage. A first phase, evidenced by artefacts, dates to the end of the fourth millennium BCE, and is in accordance with the already presumed Late Chalcolithic evidence provided by the archaeological surface finds.

A second phase, evidenced by cultural layers, dates to approximately the 27th to 24th centuries BCE. This finding has the potential to modify our understanding of the Bronze Age in the Bakırçay valley, because this dating is some hundred years younger than the previously expected timeframe based on the comparison of archaeological data. It might imply that a possibly longer duration of older pottery shapes has to be

seen in context of a more conservative pottery production continuing from the first half to the middle of the third millennium BCE in the Bakırçay valley. An explanation for this could be the fact that the Bakırçay valley was disconnected from supra-regional communication and exchange networks within the Aegean and the western Anatolian coastal region.

These results would nicely add to the picture of the Bakırçay valley already drawn by previous studies. Knitter et al. (2012, 2013) found that, in contrast to the other valleys in Western Anatolia, the Early Bronze Age sites in the Bakırçay valley were not part of the extended supra-regional exchange network based on obsidian, as no obsidian finds are known for the Early Bronze Age in the Bakırçay valley. This fact might be explained by the geographical situation which offers only restricted access to the hinterland and, thus, limited access to the major routes of exchange postulated by various authors (cf. Knitter et al., 2013).

Future investigations on the settlement at Yeni Yeldeğirmenitepe will aim to extend the preliminary results presented in this paper. Additional drilling cores will be analysed and the chronological model will be adjusted with supplementary AMS radiocarbon dates. Furthermore, the archaeological artefacts yielded by the drillings will be examined in detail and integrated into the preliminary chronological model.

Acknowledgements

The study was kindly supported by the Cluster of Excellence Exc264 TOPOI 'The Formation and Transformation of Space and Knowledge in Ancient Civilizations' (project A-I-8), the European Research Council (ERC) project 'Prehistoric Anatolia' (no. 263339) and the Austrian Science Fund (FWF) project Y 528-G02 and no. P 25825). We are thankful to Joachim Härtling and Andreas Lechner, Osnabrück University, for backing up the study and providing research infrastructure. We are especially grateful for the help of Felix Pirson and the team of the Pergamon excavation from the Istanbul Department of the German Archaeological Institute (DAI).

References

- Ad-Hoc-AG Boden, 2005. *Bodenkundliche Kartieranleitung*. Schweizerbart, Stuttgart.
- Aksu, A.E., Piper, D., Konuk, T., 1987. Late Quaternary tectonic and sedimentary history of outer Izmir and Candarli Bays, Western Turkey. *Mar. Geol.* 76, 89–104.
- Bauer, G., Wächter, K., 2001. *Ecology and Evolution of the Freshwater Mussels Unionoida*. Springer, Berlin.
- Bittel, K., 1950. Zur ältesten Besiedlungsgeschichte der unteren Kaikosebene. *Istanbulur Forschungen* 17, 10–29.
- Blättermann, M., Frechen, M., Gass, A., Hoelzmann, P., Parzinger, H., Schütt, B., 2012. Late Holocene landscape reconstruction in the Land of Seven Rivers, Kazakhstan. *Quat. Int.* 251, 42–51.
- Blegen, C., Caskey, J., Rawson, M., 1950. *Troy. General Introduction. The First and Second Settlement*. Princeton University Press, Princeton.
- Dean, W., 1974. Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition; comparison with other methods. *J. Sediment. Petrol.* 44, 242–248.
- Dilek, Y., 2006. Collision tectonics of the Mediterranean region: causes and consequences. *Geol. Soc. Am. Spec. Pap.* 409, 1–13.
- Dörpfeld, W., 1908. *Ausgrabungen in Pergamon. Technisches und Architekturtagebuch Pergamon 1908*, 16–23.
- Driehaus, J., 1957. Prähistorische Siedlungsfunde in der unteren Kaikosebene und am Golfe von Çandarlı. *Istanbulur Mitteilungen* 7, 76–101.
- Erlat, E., 2007. Climatic conditions and the Madra River Delta. In: Lambrianides, K., Spencer, N. (Eds.), *The Madra River Delta: Regional Studies on the Aegean Coast of Turkey*. The British Institute at Ankara, London, pp. 51–59.
- Erol, O., 1983. Die naturräumliche Gliederung der Türkei. Beihefte zum Tübinger Atlas des Vorderen Orients 13, 245.
- Glaubrecht, M., 1993. Mapping the diversity: geographical distribution of the freshwater snail *Melanopsis* (Gastropoda: Cerithioidea: Melanopsidae) with focus on its systematics in the Mediterranean Basin. *Mitteilungen Hamburger Zoologisches Museum und Institut* 90, 41–97.
- Horejs, B., 2009. Yeni Yeldeğirmenitepe. In: Pirson, F. (Ed.), *Pergamon – Bericht über die Arbeiten in der Kampagne 2008*. *Archäologischer Anzeiger*. 2009(2), pp. 168–174.
- Horejs, B., 2010a. Bronzezeitliche Besiedlungsmuster im Kaikostal. Interpretationen erster Surveyergebnisse im Umland von Pergamon (Türkei). In: Horejs, B., Kienlin, T. (Eds.), *Siedlung und Handwerk – Studien zu sozialen Kontexten in der Bronzezeit*. Habelt, Bonn, pp. 47–67.
- Horejs, B., 2010b. Yeni Yeldeğirmenitepe. In: Pirson, F. (Ed.), *Pergamon-Bericht über die Arbeiten in der Kampagne 2009*. *Archäologischer Anzeiger*. 2010(2), pp. 164–168.
- Horejs, B., 2011a. Neues zur Frühbronzezeit in Westanatolien. In: Blakolmer, F., Reinholdt, C., Weilharter, J., Nightingale, G. (Eds.), *Österreichische Forschungen zur Ägäischen Bronzezeit 2009*. Phoibos, Wien, pp. 157–171.
- Horejs, B., 2011b. Prähistorische Surveys am Yeni Yeldeğirmenitepe und im Umland von Pergamon. In: Pirson, F. (Ed.), *Pergamon – Bericht über die Arbeiten in der Kampagne 2010*. *Archäologischer Anzeiger*. 2011(2), pp. 146–150.
- Horejs, B., 2012a. Bergama and the Bakırçay valley in prehistory. In: Önen, E., Mutluer, M., Çetin, N. (Eds.), *Proceedings of the International Bergama Symposium*, pp. 24–36 Bergama.
- Horejs, B., 2012b. Der prähistorische Umlandsurvey. In: Pirson, F. (Ed.), *Pergamon – Bericht über die Arbeiten der Kampagne 2011*. *Archäologischer Anzeiger*. 2012(2), pp. 204–208.
- Horejs, B., 2013. Der prähistorische Umlandsurvey. In: Pirson, F. (Ed.), *Pergamon – Bericht über die Arbeiten der Kampagne 2012*. *Archäologischer Anzeiger*. 2013(2), pp. 109–117.
- Horejs, B., 2014a. The 2nd millennium BC in the Bakırçay (Kaykos) valley. An overview. In: Çınardalı-Karaaslan, N., Aykurt, A., Kolankaya-Bostancı, N., Erbil, Y.H. (Eds.), *Anadolu Kültürlerine Bir Bakış. Armağan Erkanal'a Armağan*. Hacettepe University Press, Ankara, pp. 257–274.
- Horejs, B., 2014b. Der prähistorische Umlandsurvey. In: Pirson, F. (Ed.), *Pergamon – Bericht über die Arbeiten der Kampagne 2013*. *Archäologischer Anzeiger*. 2014(2), pp. 141–146.
- Horejs, B., 2014c. Pergamon and the Kaikos Valley in Prehistoric Times. In: Pirson, F., Scholl, A. (Eds.), *Pergamon: Anadolu'da Bir Helenistik Dönem Başkenti*, pp. 106–119 Istanbul.
- Horejs, B., Weninger, B., 2016. Early Troy and its significance for the Early Bronze Age in Western Anatolia. In: Pernicka, E., Ünlüsoy, S., Blum, St. (Eds.), *Early Bronze Age Troy. Chronology, Cultural Development and Interregional Contacts*. *Studia Troica Monographien* 8. Habelt, Bonn, pp. 123–145.
- Horejs, B., Galić, A., Thanheiser, U., Wiesinger, S., 2011. Aktivitäten und Subsistenz in den Siedlungen des Çukuriçi Höyük. *Der Forschungsstand nach den Ausgrabungen 2006–2009*. *Prähistorische Zeitschrift* 86 (1), 31–66.
- Horejs, B., Milić, B., Pavúk, P., 2015. Der prähistorische Umlandsurvey. In: Pirson, F. (Ed.), *Pergamon – Bericht über die Arbeiten der Kampagne 2014*. *Archäologischer Anzeiger*. 2015(2), pp. 134–139.
- Kesgin, B., Nurlu, E., 2008. Land cover changes on the coastal zone of Candarli Bay, Turkey using remotely sensed data. *Environ. Monit. Assess.* 157, 89–96.
- Knitter, D., Bergner, M., Horejs, B., Schütt, B., Meyer, M., 2012. Concepts of centrality and models of exchange in prehistoric Western Anatolia. *eTopoi J. Ancient Studies* 3, 361–368.
- Knitter, D., Blum, H., Horejs, B., Nakoinz, O., Schütt, B., Meyer, M., 2013. Integrated centrality analysis: a diachronic comparison of selected Western Anatolian locations. *Quat. Int.* 312, 45–56.
- Lamb, W., 1936. *Excavations at Thermi in Lesbos*. Cambridge University Press, Cambridge.
- Lionello, P., Malanotte-Rizzoli, P., Boscolo, R., Alpert, P., Artale, V., Li, L., Luterbacher, J., May, W., Trigo, R., 2006. The Mediterranean climate: an overview of the main characteristics and issues. *Dev. Earth Environ. Sci.* 4, 1–26.
- Lloyd, S., Mellart, J., 1962. Beycesultan: The Chalcolithic and Early Bronze Age Levels. *Occasional Publications of the British Institute of Archaeology at Ankara*, 6. The British Institute of Archaeology at Ankara, London.
- Mouahid, A., Idaghdour, M., Ghamizi, M., Moe, H., 1996. Observation of spawn in *Melanopsis praemorsa* (Prosobranchia: Melanopsidae). *J. Molluscan Stud.* 62, 398–402.
- Pint, A., Seeliger, M., Frenzel, P., Feuser, S., Erkul, E., Berndt, C., Klein, C., Pirson, F., Brückner, H., 2015. The environs of Elaia's ancient open harbour – a reconstruction based on microfaunal evidence. *J. Archaeol. Sci.* 54, 340–355.
- Pirson, F., Horejs, B., 2014. Yılında Pergamon'un Yakın Çevresinde Gerçekleştirilen Yüzey Araştırmaları Raporu. *Araştırma Sonuçları Toplantısı* 31 (2), 299–311.
- Podzuweit, Ch., 1979. Trojanische Gefäßformen der Frühbronzezeit in Anatolien, der Ägäis und angrenzenden Gebieten. Ein Beitrag zur vergleichenden Stratigraphie. Mainz am Rhein: P. von Zabern.
- Ramsey, C.B., 2008. Deposition models for chronological records. *Quat. Sci. Rev.* 27, 42–60.
- Ramsey, C.B., 2009. Bayesian analysis of radiocarbon dates. *Radiocarbon* 51, 337–360.
- Ramsey, C.B., Lee, S., 2013. Recent and planned developments of the program OxCal. *Radiocarbon* 55, 720–730.
- Reimer, P.J., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Ramsey, C.B., Grootes, P.M., Guilderson, T.P., Hafflidason, H., Hajdas, I., Hatté, C., Heaton, T.J., Hoffmann, D.L., Hogg, A.G., Hughes, K.A., Kaiser, K.F., Kromer, B., Manning, S.W., Niu, M., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Staff, R.A., Turney, C.S.M., van der Plicht, J., 2013. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 Years cal BP. *Radiocarbon* 55, 1869–1887.
- Schneider, S., Nykamp, M., Matthaei, A., Bebermeier, W., Schütt, B., 2013. Alluvial geoarchaeology of a small drainage basin in western Anatolia: late Holocene landscape development and the question of the mouth of the Paleo-Bakırçay. *Quat. Int.* 312, 84–95.
- Schneider, S., Matthaei, A., Bebermeier, W., Schütt, B., 2014. Late Holocene human-environmental interactions in the Eastern Mediterranean: settlement history and paleogeography of an ancient Aegean hill-top settlement. *Quat. Int.* 324, 84–98.
- Schneider, S., Matthaei, A., Schlöf, M., Meyer, C., Kronwald, M., Pint, A., Schütt, B., 2015. A geoarchaeological case study in the chora of Pergamon, western Turkey, to reconstruct the late Holocene landscape development and settlement history. *Quat. Int.* 367, 62–76.
- Seeliger, M., Brill, D., Feuser, S., Bartz, M., Erkul, E., Kelterbaum, D., Vött, A., Klein, C., Pirson, F., Brückner, H., 2014. The purpose and age of underwater walls in the bay of Elaia of western Turkey: a multidisciplinary approach. *Geoarchaeology* 29, 138–155.
- Sutherland, R.A., 1998. Loss-on-ignition estimates of organic matter and relationships to organic carbon in fluvial bed sediments. *Hydrobiologia* 389, 153–167.