# Palaeoecology of submerged prehistoric settlements in Sozopol Harbour, Bulgaria

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# Contents

19

# Palaeoecology of Submerged Prehistoric Settlements in Sozopol Harbour, Bulgaria

*Mariana Filipova-Marinova, Liviu Giosan, Hristina Angelova, Anton Preisinger, Danail Pavlov and Stoyan Vergiev*

*In addition to archaeological and geological investigation of submerged prehistoric settlements in the harbour of Sozopol (southern Bulgarian Black Sea coast), two cores were analyzed for pollen and spores, dinoflagellate cysts, non-pollen palynomorphs, and micro-charcoal. The cores provide detailed information about the vegetation and climate of periods with abundant archaeological evidence. Four local pollen assemblage zones based on arboreal pollen/non-arboreal pollen (AP/NAP) ratios are distinguished. A detailed reconstruction of the past vegetation reveals the extent of anthropogenic influence on the area. Three AMS radiocarbon determinations show that the palaeoecological record starts at* c. *4139 cal BC. The palynological and geoarchaeological data confirm the existence of anthropogenic activity and settlement during the final stage of the Late Eneolithic (*c. *4100–3850 cal BC) and the second phase of the Early Bronze Age (*c. *3500–2650 cal BC). These two archaeological cultural stages were interrupted for about 500–1000 years because of the rise in the level of the Black Sea, as suggested by the increase of euryhaline marine dinoflagellate cysts, and/or land subsidence.*

**Keywords**: Black Sea, sea-level rise, Sozopol harbour, Eneolithic, Chalcolithic, Bronze Age, palaeoecology, human impacts, vegetation change

## Introduction

The rich archaeological record along the south-western Black Sea coast has attracted the attention of many scientists in different fields of investigation. The submerged prehistoric settlements in the harbour of Sozopol (Fig. 19.1) have yielded remains of the Late Eneolithic (Eneolithic is also known as Chalcolithic or Copper Age) and Early Bronze Age (Draganov 1995, 1998; Angelova and Draganov 2003). Archaeological evidence of human occupation during the Bronze Age has also been found in the nearby Bay of Urdoviza (Kiten) (Porozhanov 1991).

Valuable palynological information relating to the palaeoenvironmental conditions of the southern Bulgarian Black Sea coast (vegetation, climate, and sea-level fluctuations) is available from studies of lacustrine and marine sediments, and from sediments of the Veleka River estuary (Bozilova and Beug 1992; Filipova-Marinova 2003a, 2003b, 2007; Wright *et al.* 2003; Filipova-Marinova *et al.* 2004; Atanassova 2005). However, evidence relating to human activity is insignificant in these previous studies.

Some information about palaeoecological conditions and especially about human impact on vegetation comes from palynological investigations of the core from Quadrant 'F' from the Bay of Urdoviza (Kiten), 10 km south of Sozopol (Bozilova and Filipova-Marinova 1994). The pollen diagrams generally demonstrated a long period of forest development for the greater part of the Holocene interrupted by distinct phases of human activity during the Early Bronze Age (Kuniholm *et al.* 2007).

The aim of the present investigation is to trace changes in environment and human activity along the southern Bulgarian Black Sea coast. To address this question, two cores from Sozopol harbour were analyzed for pollen, dinoflagellate cysts, and other non-pollen palynomorphs (NPP). Radiocarbon dating was also performed.

## The study area

### *Topography and geology*

The southern Bulgarian Black Sea coast (Fig. 19.1) consists of sandy bays with lagoon lakes interrupted by rock ridges. Rocky slopes gradually rise up to about 200–400 m altitude at a distance of *c.* 3–4 km from the coast. Ridges, slopes, and mountains are composed of andesite and syenite. In the area investigated geological faults run from the Strandzha Mountains to the Black Sea (Kanev 1960).

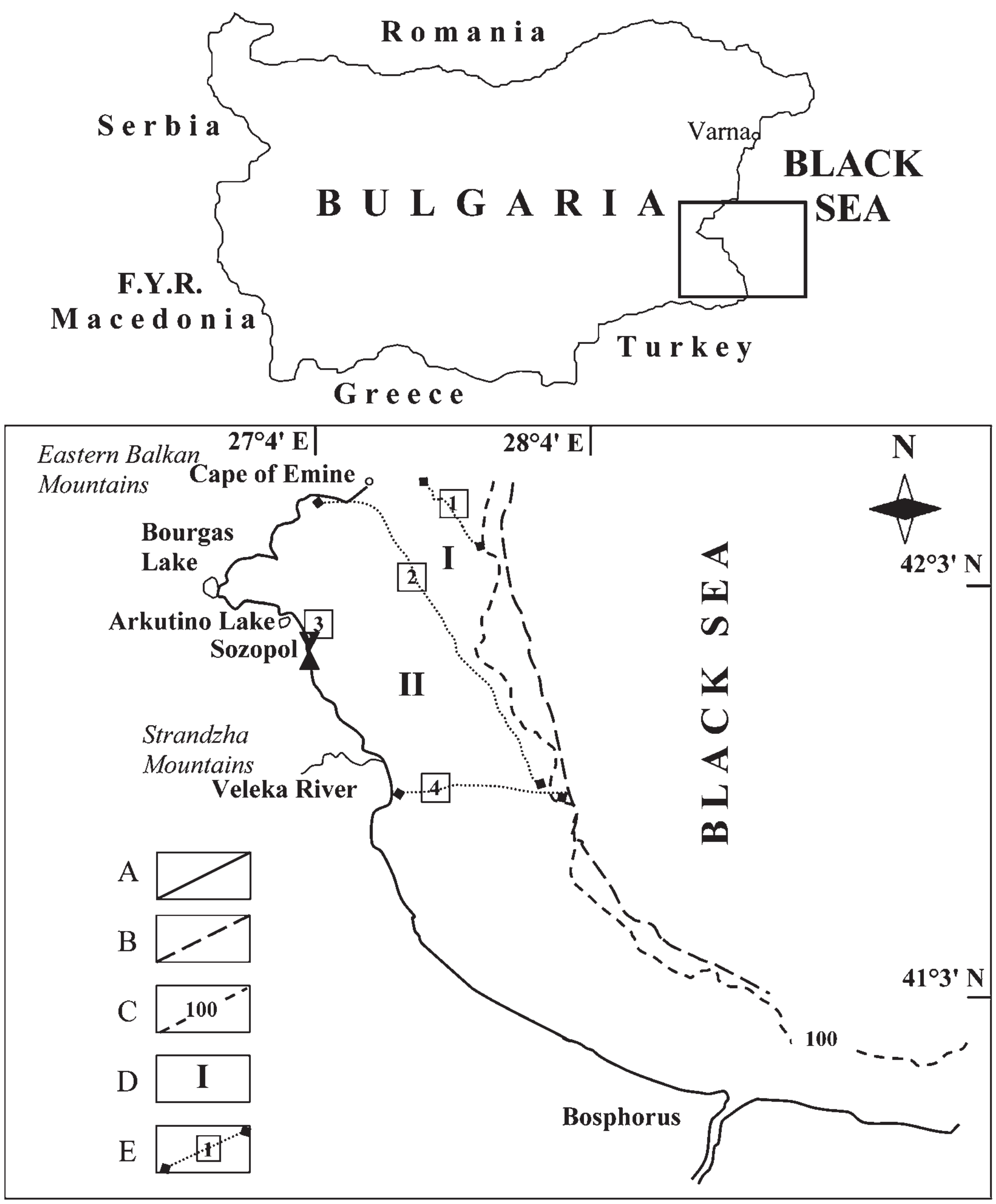


*Figure 19.1: Schematic diagram of the area investigated. A: Coastline; B: Boundary between the shelf and the continental slope; C: 100 m isobaths; D: Basic tectonic zones, I Eastern Balkan Range, II Bourgas Depression; E: Basic fault zones reflected in the bottom relief, 1 Pre-Balkan fault, 2 Hind Balkan fault, 3 Sozopol fault, 4 Eastern Rezovo fault*

***Climate***

Along the Southern Bulgarian Black Sea coast the climate is transitional Mediterranean with dry summers and mild, humid winters. Mean annual precipitation is estimated to be 500–600 mm, with most rainfall during the autumn–winter season. Mean January temperature is 2–3°C, and mean July temperature is 22°C. The summer dry period lasts from July to September. Winds come mostly from the southeast, but occasionally from the northeast (Velev 2002).

***Vegetation***

According to Bondev (2002) the area is included in the Black Sea province of the European deciduous forest area. Near the Black Sea coast, forests with some Mediterranean elements such as *Carpinus orientalis* Mill., *Phillyrea latifolia* L., *Fraxinus ornus* L., *Quercus pubescens* Willd., and *Celtis australis* L. occur. Forests of the more continental species occur on lowland sites and hills and in the Strandzha Mountains. They are mainly composed of *Quercus cerris* L., *Quercus frainetto* Ten., *Quercus polycarpa* Schur., and *Carpinus betulus* L. South Euxinian forests of *Fagus orientalis* Lipsky with undergrowth of evergreen shrubs (*Rhododendron ponticum* L., *Ilex aquifolium* L., and *Daphne pontica* L.) are distributed along the more humid ravines in the Strandzha Mountains. Periodically flooded forests (known as 'Longoz') dominated by *Fraxinus oxycarpa* Willd., *Ulmus minor* Mill., *Carpinus betulus* L., *Quercus pedunculiflora* C. Koch, and *Alnus glutinosa* (L.) Gaerth. with lianas (woody vines), including *Hedera helix* L., *Periploca graeca* L., *Smilax excelsa* L., *Vitis vinifera* L., and *Clematis vitalba* L. occur along the rivers and lakes. Herb communities with a prevalence of *Leymus racemosus* (Lam.) Tzvelev ssp. *sabulosus* Hochst, *Ammophilla arenaria* (L.) Link, *Centaurea arenaria* Bieb. ex Willd, and *Galilea mucronata* (L.) Pal., as well as shrub communities with a prevalence of *Cionura erecta* (L.) Grsb., are distributed on beach sand and dunes.

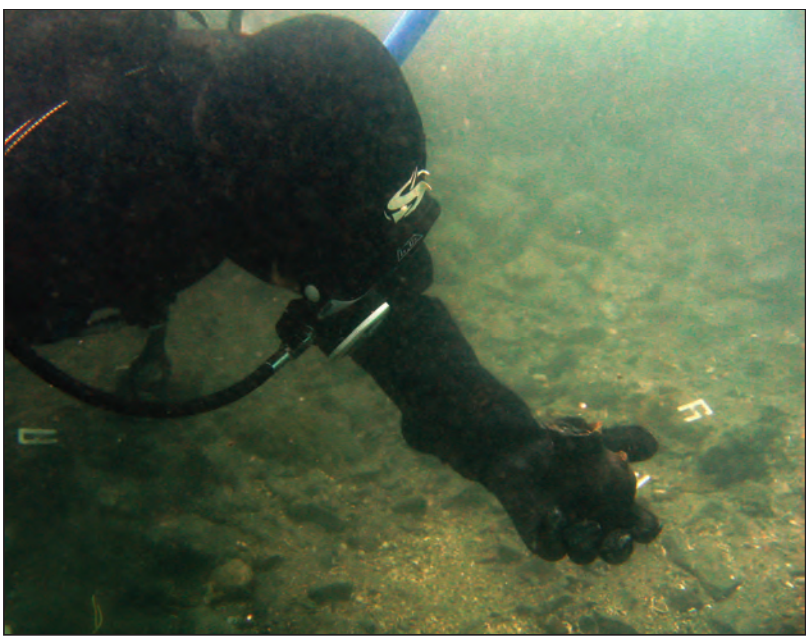

*Figure 19.2: Excavation of the Early Bronze Age layer of the submerged settlement in Sozopol harbour (Photo: H. Angelova)*

***Archaeological background***

Underwater archaeological investigations at the Bulgarian Black Sea coast over the past 20 years have made it possible to collect some information about submerged prehistoric settlements. These settlements belong to two chronological periods. Some of the prehistoric settlements (e.g. Varna and Sozopol) were founded during the Late Eneolithic. The Late Eneolithic settlement in Sozopol harbour can be placed between the end of Varna Culture (phase III, *c.* 4340 cal BC) and the beginning of the Cernavoda I Culture (*c.* 4100 cal BC). Draganov (1995) dated the Late Eneolithic in Sozopol between 4100 and 3850 cal BC. The dendrochronological data of oak piles (Figs 19.3 and 19.4) retrieved from the Late Eneolithic site in Sozopol harbour, *c.* 7 m below present sea level, show a 224-year tree ring chronology and an AMS radiocarbon determination of *c.* 4140 cal BC (Kuniholm *et al.* 2007). The Eneolithic settlements in Sozopol harbour were either flooded owing to sea-level rise or because of tectonic subsidence. The date of this inundation corresponds to the archaeological hiatus known as the 'Transitional Period', dated in Bulgaria at 4000–3200 cal BC (Bojadziev 1995).

After 3200 cal BC the sea began to withdraw and the Bay of Sozopol became habitable once more. Some Early Bronze Age settlements then developed on the remains of the Late Eneolithic settlements (e.g. Sozopol); others sprang up in entirely new locations (e.g. Atiya, Ropotamo, Urdoviza, and Akhtopol). These settlements existed mainly during the second phase of the Early Bronze Age (2780–2504 cal BC; Ezerovo Culture, phases VI–V) (Bojadziev 1995). The nearby, submerged settlement of Urdoviza (Kiten) is dated to 2850–2600 cal BC (Görsdorf and Bojadziev 1997) and could be compared to the Cernavoda–Ezerovo Culture

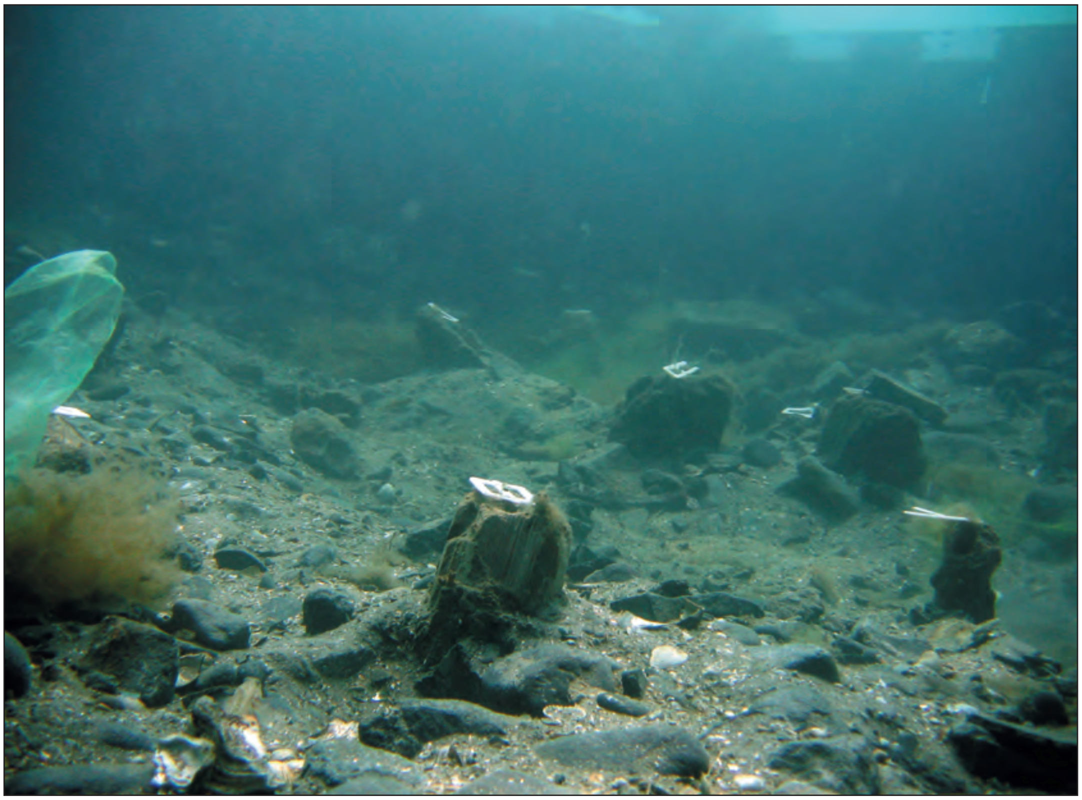

*Figure 19.3: Vertical piles in Sozopol harbour, dated by dendrochronology to the Eneolithic period (Photo: H. Angelova)*

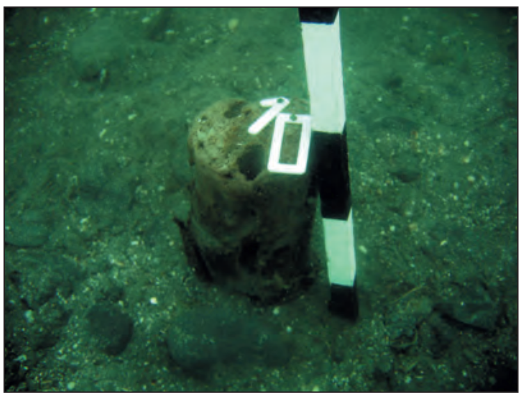

*Figure 19.4: Eneolithic pile. Prior to the archaeological excavation its upper end was shaped by erosion and biological decomposition at the seafloor. The vertical holes in the timber are made by piddocks (*Pholadidae*) (Photo: H. Angelova)*

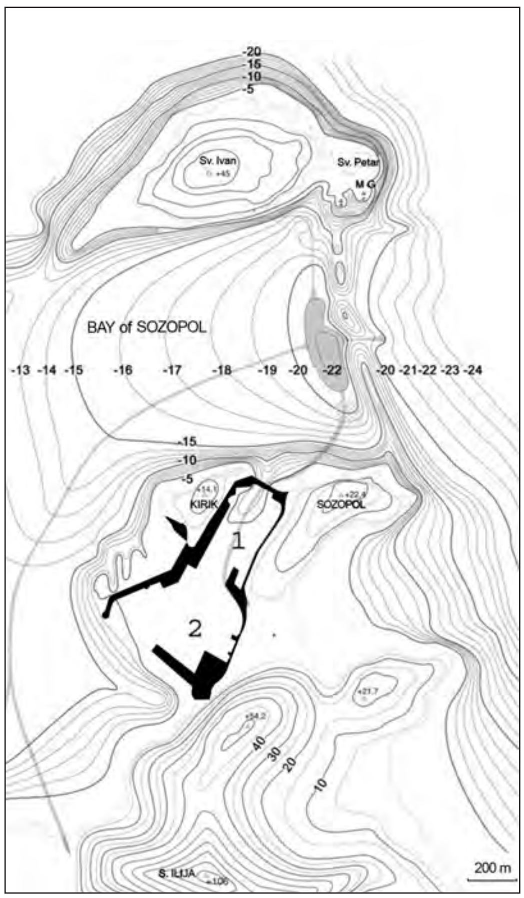


*Figure 19.5: Geomorphological and bathymetric map of the Bay of Sozopol with the location of both investigation zones of the prehistoric settlements indicated*

(Ezero VI–IX, 2900–2700 cal BC) (Kuniholm *et al.* 2007). Dendrochronological analysis of preserved wooden piles shows that this prehistoric settlement has the longest Early Bronze Age chronology (224 years) in the Balkan and Aegean area (Kuniholm *et al.* 1998, 2007).

## Material and methods

### *Coring*

The Bay of Sozopol is situated in the southwestern Black Sea area (Fig. 19.1). Three islands occur in the area: Kirik, Sveti Ivan, and Sveti Petar (Fig. 19.5). Sozopol harbour includes two zones of investigation: Sozopol-1 and Sozopol-2.

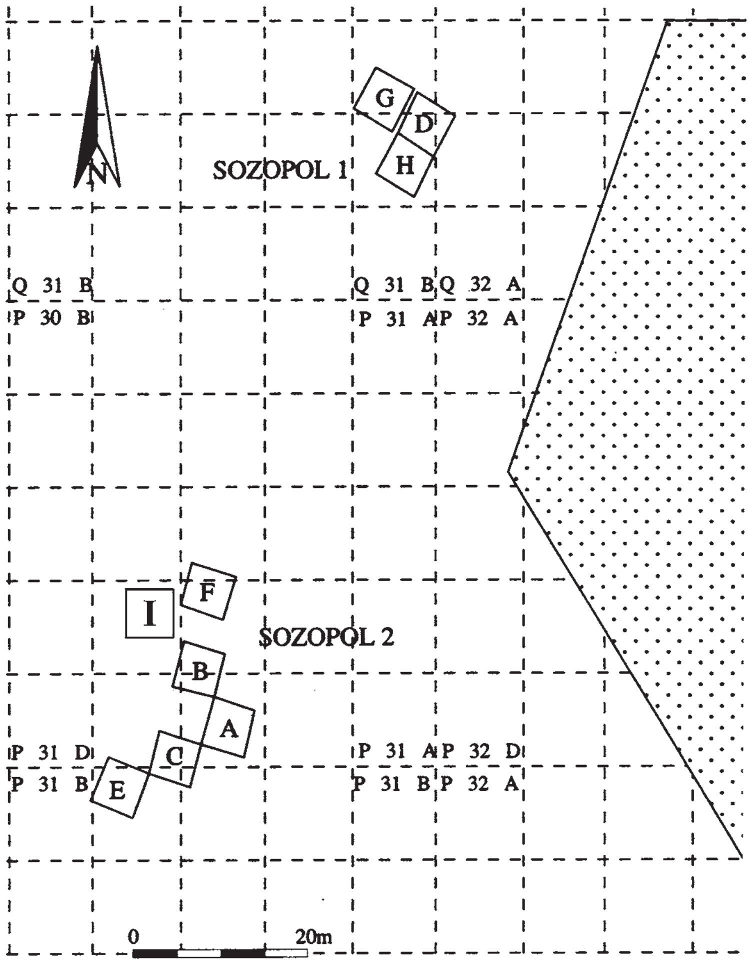


*Figure 19.6: Schematic diagram of the location of the investigated quadrants in Sozopol harbour*

A grid was laid over the site with the aid of theodolites located on shore. The working squares (5 × 5 m) formed part of larger squares (100 × 100 m) that were connected to topographical altitudes noted on the shore. To assist stratigraphical observations a rigid square network made of solid metal sheets was put in place. The seabed was removed in layers of 5–10 cm by ejectors and a low-pressure compressor. Nine connected quadrants, 5 × 5 m in size, were excavated in these zones (Fig. 19.6). Three of the quadrants contain only Early Bronze Age material (A, C, and E), three contain Early Bronze Age material and, below a hiatus, Eneolithic material (B, F, and I), and three contain only Eneolithic material (D, G, and H). During the construction of the harbour the overlying sediments in quadrants D, G, and H were damaged.

The material for the present investigation was collected using *Dachnowsky* coring equipment from two submerged settlements (Figs 19.5 and 19.6):

- Sozopol-1 investigation zone – Quadrant 'D' (210 cm core), water depth 4.3–4.6 m, with coordinates 42°25′85″ N, 27°41′88″ E;
- Sozopol-2 investigation zone – Quadrant 'I' (190 cm core), water depth 5.0–5.1 m, with coordinates 42°25′88″ N, 27°41′41″ E.

### *Radiocarbon dating*

Two samples of wood from core 'I' and one sample also of wood from core 'D' from the levels where anthropogenic indicators started to increase were submitted for AMS dating. The radiocarbon dates on core 'I' were done at the Woods Hole Oceanographic Institute and on core 'D' at the VERA Laboratory of the University of Vienna. The results are shown in Table 19.1. The data cover the time span between *c.* 4139 cal BC and *c.* 3227 cal BC, and correspond to the Late Eneolithic and Early Bronze Age according to the radiocarbon data for Bulgarian prehistory (Görsdorf and Bojadziev 1997).

### *Pollen analysis*

Samples for pollen analysis were taken every 10 cm through the core and processed according to the acetolysis method (Faegri and Iversen 1989) slightly modified to remove the mineral component with hydrofluoric acid (Birks and Birks 1980). By this procedure, some dinoflagellate cysts can be lost. Pollen types were determined by comparison with the reference collection of the Museum of Natural History

*Table 19.1: AMS radiocarbon determinations for Sozopol cores 'I' and 'D'. The samples dated were single pieces of wood. Calibrations performed with CALIB 6.0 (Stuiver and Reimer 1993; Stuiver* et al. *2005), using the IntCal09 curve (Reimer* et al. *2009)*

| Core/Lab. ID | Depth (cm) | $^{14}$C Age BP | Median Probability Age (cal BP) | Median Probability Age (cal BC) | Material dated |
|---|---|---|---|---|---|
| Sz-I/OS-58077 | 35–45 | 4560±40 | 5177 | 3227 | Charcoal |
| Sz-I/OS-57882 | 155–165 | 5170±30 | 5929 | 3979 | Charcoal |
| Sz-D/VERA-1652 | 65–70 | 5310±40 | 6089 | 4139 | Uncarbonized wood |

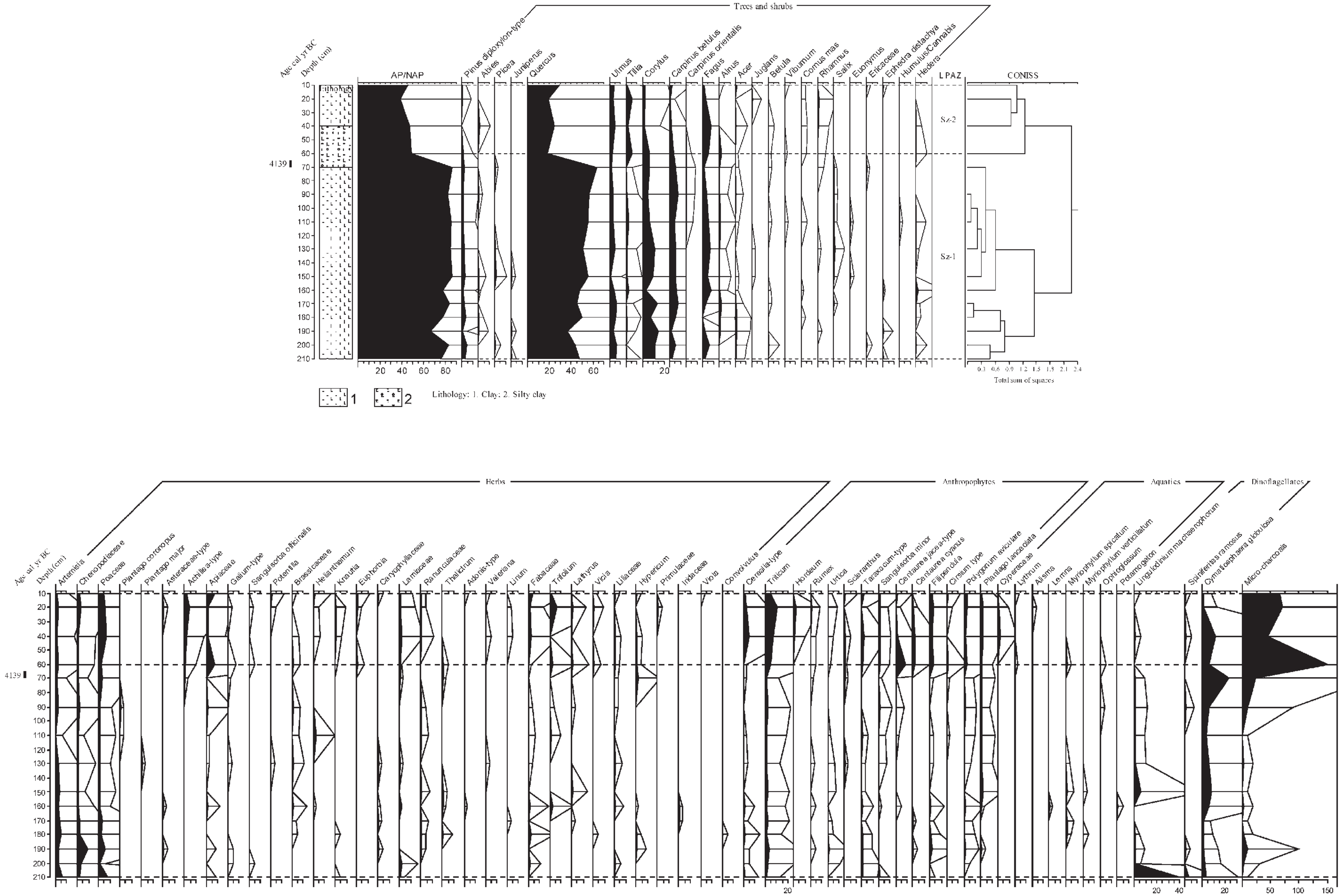


*Figure 19.7: Percentage pollen diagram of the core from quadrant 'D' of the submerged prehistoric settlement in Sozopol harbour*

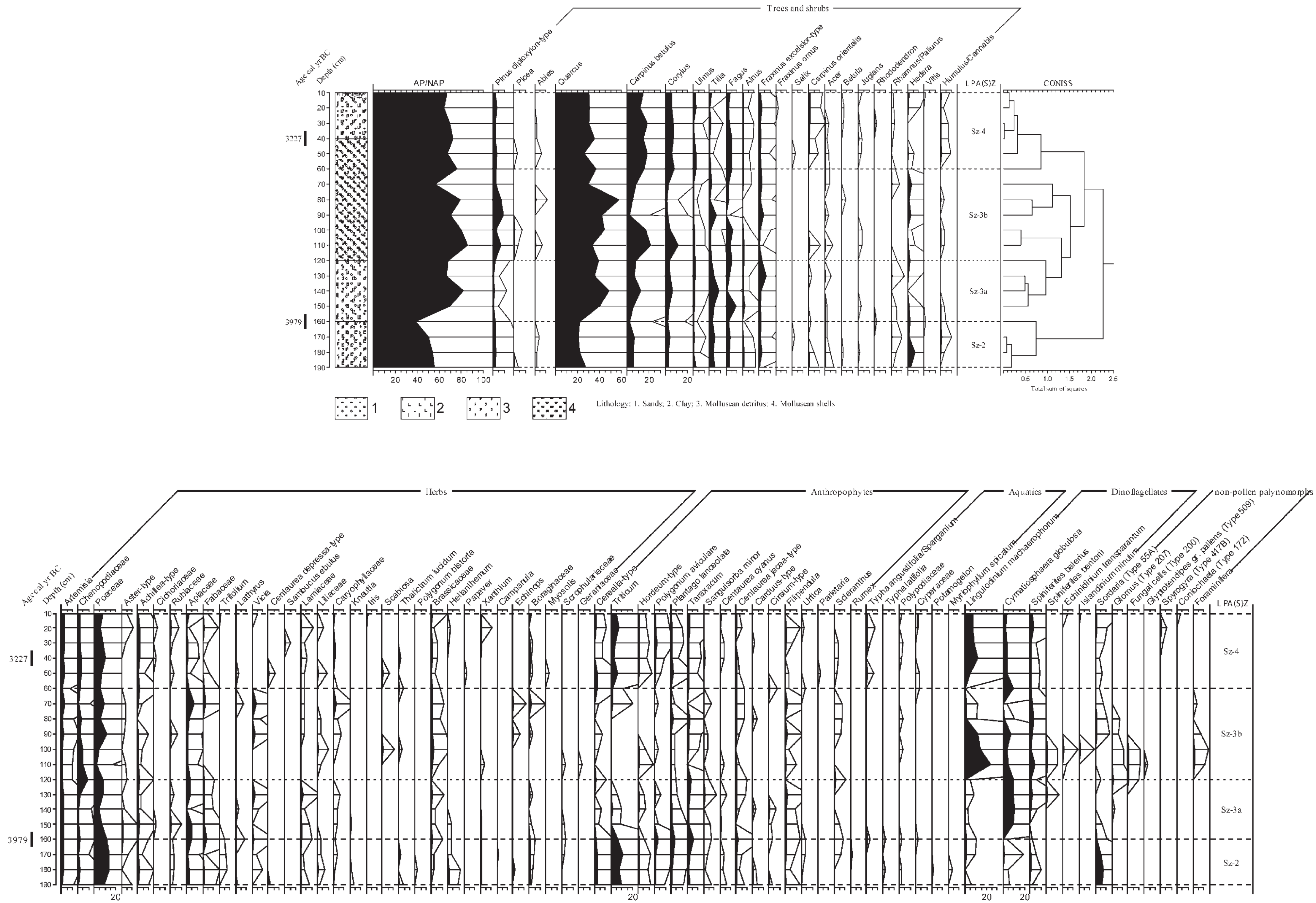


*Figure 19.8: Percentage pollen diagram of the core from quadrant 'I' of the submerged prehistoric settlement in Sozopol harbour*

of Varna and the keys of Erdtman *et al.* (1961), Beug (1961, 2004), Moore and Webb (1978), Faegri and Iversen (1989), and Reille (1992, 1995). For non-pollen palynomorphs (NPP) the keys of Van Geel and colleagues (Van Hoeve and Hendrikse 1998; Van Geel 2001) were used. The publications of Wall *et al.* (1973), Wall and Dale (1974), Rochon *et al.* (1999), Marret and Zonneveld (2003), and Mudie *et al.* (2001, 2004) were used for the determination of dinoflagellate cysts and acritarchs.

Up to 600 pollen grains of terrestrial plants were counted per sample. The dinoflagellate cysts, other NPP (only for Core 'I'), and charcoal fragments >10 μm (only for Core 'D') were counted on the pollen slides. The percentage values of the pollen taxa were calculated on the basis of AP+NAP sum (arboreal plus non-arboreal plants excluding aquatics, dinoflagellate cysts, and other NPP). The frequency of the micro-charcoal and the dinoflagellate cysts is also presented in percentages on the basis of this pollen sum. Dinoflagellate cysts of *Lingulodinium machaerophorum* in the diagram include forms with long non-clavate and reduced clavate processes.

Based on the most abundant arboreal taxa and anthropogenic indicators, the pollen percentage diagrams (Figs 19.7 and 19.8) were divided into four local pollen assemblage zones (LPAZ Sz-1 to LPAZ Sz-4) with two sub-zones (LPASZ Sz-3a, 3b) to facilitate description and understanding of the vegetation succession. Cluster analysis CONISS (Grimm 1987) was applied for zonation. The zones are numbered from the base upwards and prefixed by the site designation (Sz). The computer programs TILIA v.2.0.b.4 and TGVIEW v.2.0.2. (Grimm 1991, 2004) were used for pollen percentage calculations. For the purposes of comparison, the archaeological chronology for the western Black Sea Coast (Todorova 1986), the chronostratigraphic scheme of the western Black Sea shelf (Shopov 1991), and the Blytt (1876)–Sernander (1908) climatostratigraphic subdivisions of the Holocene were used.

## Results

The location of the two cores from the settlements of Sozopol-1 and Sozopol-2 provide excellent possibilities for the correlation of palynological and archaeological data, and for reconstructing the environmental conditions and anthropogenic influence in the area. Important preconditions for such comparisons are AMS radiocarbon dates that fall within the time interval *c.* 4139–3227 cal BC, relating to the Late Eneolithic and Early Bronze Age in conformity with the radiocarbon chronology for Bulgarian prehistory (Görsdorf and Bojadziev 1997).

The four local pollen assemblage zones of Sozopol harbour can be characterized as follows:

### *LPAZ Sz-1 (*Quercus–Corylus–Carpinus betulus*)*

This LPAZ is represented only in core 'D'. Pollen data show that mixed-oak forests are widespread because of the high temperature and humidity. The constant, but low, percentage values of *Triticum* and Cerealia-type pollen found in this zone probably belong to wild species, and were not the result of human activity. For example, *Triticum boeoticum* Boiss is recently naturally distributed in the southern Bulgarian Black Sea coast (Kozhuharov 1986). The low impact of human activity is also suggested by the lack of palaeofires inferred from insignificant amounts of micro-charcoal.

### *LPAZ Sz-2 (*Quercus–Tilia–Fagus–*Poaceae*–Triticum*)*

This zone is determined in both cores investigated. The palaeoecological record correlates with the Eneolithic period according to the AMS dates of *c.* 4139 and 3979 cal BC from the base of cores 'D' and 'I', respectively. In this zone all arboreal taxa are present with lower frequencies (AP=38.7%) compared to the previous LPAZ Sz-1 of Core 'D' (Table 19.2). The source areas for arboreal pollen were the deciduous forests around the Bay of Sozopol and on the Strandzha Mountains (30 km south of the area investigated), where the environmental conditions during the climatic optimum of the Holocene were extremely favourable for temperate deciduous forests (Filipova-Marinova 2003a). The AP values can be attributed to different species of *Quercus* and partly to *Fagus*, *Ulmus*, *Tilia*, *Fraxinus excelsior*, *Carpinus betulus*, and *Corylus*. The presence of lianas such as *Hedera* and *Humulus* confirms the increase of annual temperatures and moisture. Low pollen percentages of *Pinus diploxylon*-type, *Abies*, and *Picea* in the fossil record reflect long distance transport from the southern Black Sea area.

Cultivated cereals including *Triticum*, weeds

*Table 19.2: Correlation of local pollen assemblage zones (LPAZ) and sub-zones (LPASZ) in cores taken from the submerged prehistoric settlements in Sozopol harbour*

<table>
<tr><th colspan="2" rowspan="2">Northern European climatostratigraphy (Blytt 1876 – Sernander 1908)</th><th colspan="2" rowspan="2">Chrono-stratigraphic scheme of the western Black Sea shelf (Shopov 1991)</th><th rowspan="2">Archaeological chronology for the western Black Sea coast (Todorova 1986)</th><th colspan="3">Sozopol-I</th><th colspan="2">Sozopol-D</th></tr>
<tr><th>Local PAZ</th><th>Local PASZ</th><th>Pollen assemblages</th><th>Local PAZ</th><th>Pollen assemblages</th></tr>
<tr><td rowspan="6">HOLOCENE</td><td>Subatlantic</td><td rowspan="6">BLACK SEA</td><td>New Black Sea</td><td>Iron Age</td><td colspan="3"></td><td colspan="2" rowspan="4"></td></tr>
<tr><td>Subboreal</td><td rowspan="5">Old Black Sea</td><td>Bronze Age</td><td colspan="2">4</td><td>Quercus, Carpinus betulus, Corylus, Ulmus, Fagus, Triticum</td></tr>
<tr><td rowspan="4">Atlantic</td><td rowspan="2">Transitional Period</td><td rowspan="2">3</td><td>b</td><td>Quercus, Carpinus betulus, Corylus, Tilia, Fagus</td></tr>
<tr><td>a</td><td>Quercus, Tilia, Corylus, Fagus, Carpinus betulus</td></tr>
<tr><td rowspan="2">Eneolithic (Chalcolithic)</td><td colspan="2">2</td><td>Quercus, Tilia, Fagus, Poaceae, Triticum</td><td>2</td><td>Quercus, Corylus, Carpinus betulus, Fagus, Cerealia</td></tr>
<tr><td colspan="3"></td><td>1</td><td>Quercus, Corylus, Carpinus betulus</td></tr>
</table>

(*Centaurea cyanus)*, and ruderals such as *Plantago lanceolata*, *Polygonum aviculare*, *Filipendula*, and *Rumex*, are recorded in this zone, indicating the existence of the Late Eneolithic settlement in the area, and suggest that human activity was the main reason for reduction in the area covered by mixed-oak forests. According to bathymetric measurements (Preisinger *et al.* 2004) (Fig. 19.9A), the Late Eneolithic settlement was located along the Patovska River estuary, on a river terrace 70–80 m wide from east to west with a slight slope of 5–6% to the southwest.

The low percentage values of marine dinoflagellate cysts and the presence of pollen of aquatic species such as *Myriophyllum spicatum* and *Potamogeton* suggest low sea level at this time. The presence of NPP *Spyrogira* (Type 417B) suggests a brackish water environment and stagnant, shallow, open, relatively eutrophic (well-nourished) water at least during the spring. The freshwater–brackish diatom complex established by Ognjanova-Rumenova (1995) in Core ‘D’ also provides evidence for low water level. The high water table was the main reason that oak piles were used for stabilizing the ground on which the horizontal wooden constructions of the settlement were built (Draganov 1995). Soils near the settlement were moist, rich in humus, and suitable for cultivation. According to Bakels (1978), in the selection of habitation areas, the availability of good arable land near the settlement, called the ‘home range’, had decisive significance.

The cultivated cereals considered by Behre (1990) as primary anthropogenic indicators are well represented throughout the entire zone and point to intensive agriculture near the settlement. The significant percentages of *Triticum* and *Hordeum*-type pollen are consistent with palaeoethnobotanical data for the Bulgarian Black Sea coast (Behre 1990; Popova and Bozilova 1998; Marinova 2003), suggesting

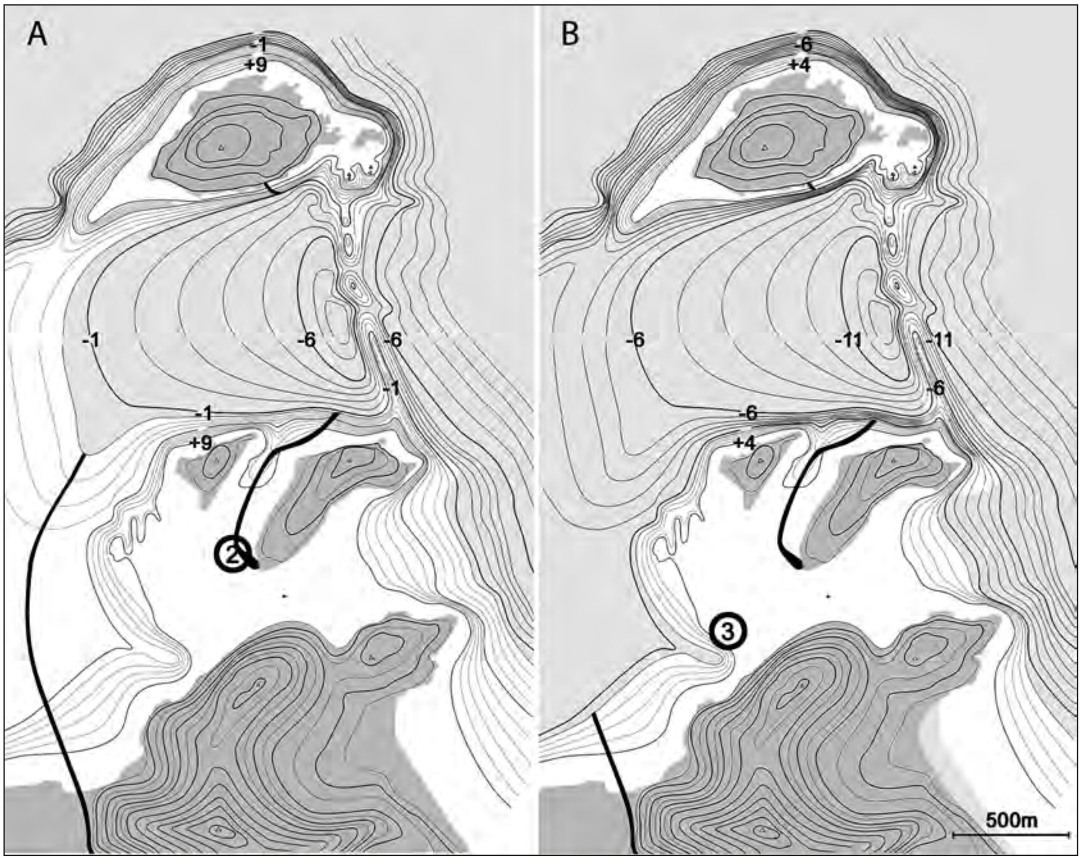


*Figure 19.9: Schematic diagram of reconstructed coastlines of the Bay of Sozopol, A: Coastline at* c. *4000 cal BC with the location of the Eneolithic settlement (2), and B: Coastline at* c. *2600 cal BC with the location of the Bronze Age settlement (3)*

that *Triticum monococcum*, *T. dicoccum*, *T. aestivum*, and *Hordeum vulgare* were the main crops during the Late Eneolithic. The secondary anthropogenic indicators, including the cereal crop weed *Centaurea cyanus* also indicate farming. The development of farming around the settlement is confirmed by the archaeological finds of vessels and agricultural tools. However, the settlement has yet to be fully investigated, and the tools recovered are not sufficient to determine the extent of farming and agrarian practices.

The low pollen values for weeds could be explained by the manner of harvesting. According to Todorova (1979) stems were cut below the wheatears, and thus weed grains could not fall among the seedcorn. According to Behre (1990) it is the result of dividing weed grains from the seed crop after harvesting, because more weed grains were found in samples from drying ovens than in samples from pits for crop storage.

Palynological data confirm the archaeological information of Todorova (1979) that agriculture was the basis of the Eneolithic economy along the Bulgarian Black Sea coast. The occurrence of ruderals such as *Polygonum aviculare*, *Sanguisorba minor*, and components of wet meadows and pastures such as *Plantago lanceolata*, *Filipendula*, *Carduus*-type, *Cirsium*-type, and *Rumex* indicates pasture formation and stockbreeding (Figs 19.7 and 19.8). *Plantago lanceolata* is considered one of the most reliable secondary anthropogenic indicators and it is widely used to trace the increased activity of prehistoric man, especially stockbreeding and consequently grazing, because of its ability to spread on soils influenced by human activity (Behre 1990; Bottema and Woldring 1990). *Artemisia* and Chenopodiaceae pollen cannot be considered reliable anthropogenic indicators in this coastal area; it is difficult to determine if the pollen of these taxa is natural or a result of human activities because they are components of recent vegetation. The presence of dung indicators such as ascospores of *Sordaria* (Type 55 of NPP) and *Coniochaeta* (Type 172) which, according to Van Geel and colleagues (Van Hoeve and Hendrikse 1998), occur in eutrophic to mesotrophic environments, indicates habitats rich in nitrates. This is confirmed by the presence of *Urtica* pollen, which is characteristic of nitrogen-rich cultivated areas (Figs 19.4 and 19.5).

The peak of microscopic charcoal coincides with anthropogenic indicators and with NPP, indicating a eutrophic to mesotrophic environment. According to Mehringer *et al.* (1977) the presence of micro-charcoal indicates that forest fires in the past could be not only of meteorological but also anthropogenic origin. The maximum occurrence of micro-charcoal at level 60 cm in core 'D', the recovery of charred wood from both submerged settlements, and the charring observed on ceramics suggest that fire was also used for the enlargement of arable areas (Draganov 1998).

With regard to the occurrence of cultivated trees, it should be noted that the first trace of walnut (*Juglans)* at Sozopol is recorded after *c.* 4139 cal BC (Fig. 19.7). However, the question of whether the presence of this taxon in the pollen diagrams is connected with human culture or is a result of its natural spread along the coast is debatable. The earliest appearance of single pollen grains of *Juglans* along the Bulgarian Black Sea coast during the Holocene is dated at *c.* 9090 cal BC (Filipova-Marinova 2003a), confirming the relict origin of this taxon in the Balkan Peninsula (Velchev 1971; Bottema 1980; Bozilova 1986).

The available AMS dates (*c.* 4139 and 3979 cal BC), palynological and stratigraphic data, as well as the archaeological finds from the submerged prehistoric settlements in Sozopol harbour, provide evidence of cultural development in the area at the final stage of the Late Eneolithic (4100–4000 cal BC).

***LPAZ Sz-3***

LPAZ Sz-3 is determined in Core 'I' and is divided into two local pollen assemblage sub-zones: LPASZ Sz-3a (*Quercus–Tilia–Corylus–Fagus–Carpinus betulus*) and LPASZ Sz-3b (*Quercus–Carpinus betulus–Corylus–Tilia–Fagus*)

In this zone the AP/NAP ratio suggests enlargement of areas covered by forest vegetation as a result of increased temperature and moisture. Considering the observed peaks of *Quercus*, *Tilia*, *Ulmus*, *Fraxinus excelsior*-type pollen and *Hedera*, this zone most likely represents mixed-oak forest. This must have formed compact communities since the herb pollen taxa show low percentages. A characteristic feature is the significant increase of *Carpinus betulus* together with the decrease of *Quercus*. *Carpinus betulus* is a constituent of mixed-oak forests but the maximum pollen content of 21% in LPASZ Sz-3b suggests that this species probably formed detached monodominant communities in restricted areas as well. The increase of *Carpinus betulus* is due to the migration of this taxon from refugia in the Strandzha Mountains (Filipova-Marinova 2003b). This characteristic vegetation succession and the available AMS radiocarbon date of *c.* 3979 cal BC correlate this zone with the end of the Atlantic.

High percentages of *Carpinus betulus* were also found in other reference sites on the southern Bulgarian Black Sea coast, e.g. Arkutino Lake (Bozilova and Beug 1992), the Veleka River estuary (Filipova-Marinova 2003a), and deep sea Core 544 (Filipova *et al.* 1989). A period of vast spread of *Carpinus betulus* and formation of detached forest belt during the end of Atlantic and the beginning of the Subboreal was also established for the Balkan Mountains (Filipovitch *et al.* 1998). Beech forests, most probably of *Fagus orientalis*, also enlarged their distribution along the humid ravines in the Strandzha Mountains. The presence of *Glomus* (Type 207 of NPP) and fungal cells (Type 200 of NPP) is attributed to an increase in arboreal vegetation.

The sharp decrease of cereal pollen and the gap in cultural development confirms a cultural hiatus of about 500–1000 years between the final stage of the Late Eneolithic and the Early Bronze Age along the Bulgarian Black Sea coast associated with diminishing human population in the area (Todorova 1986). According to Todorova (2002) the Eneolithic cultures in the northeastern part of the Balkan Peninsula had vanished by *c.* 4200 cal BC.

The maximum values of cysts of euryhaline marine dinoflagellates *Lingulodinium machaerophorum*, *Spiniferites belerius*, *Spiniferites ben-*

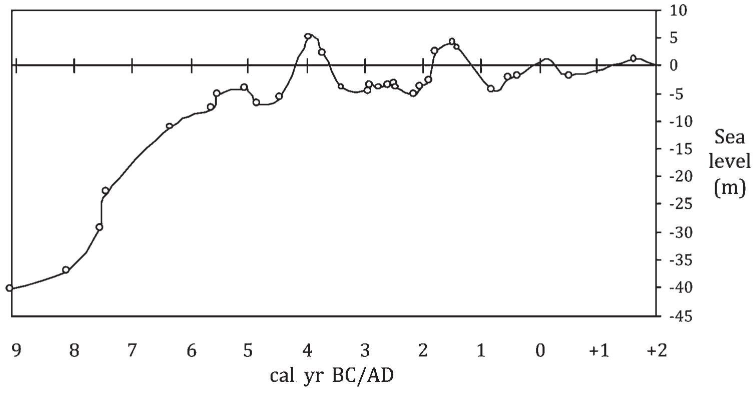


*Figure 19.10: Holocene sea-level curve for the Black Sea (Adapted from Filipova-Marinova 2007)*

*thorii* and *Islandinium minutum*, acritarchs *Cymatiosphaera globulosa*, as well as foraminifera correlate with the domination of planktonic brackish diatom species (Ognjanova-Rumenova *et al*. 1998) and the replacement of clay sediments by more terrigenous ones. Sea level rose and influenced the area during the Black Sea post-Eneolithic transgression (Chepalyga 2002; Filipova-Marinova 2007) (Fig. 19.10). This supports the assumption that the settlements were abandoned. According to the archaeological chronology this zone corresponds with the Transitional Period (post-Eneolithic, proto-Bronze Age) and has been dated by Vajsov (2002) to 4150–3200 cal BC. For the southern part of the Bulgarian Black Sea coast and for the area of submerged prehistoric settlements in Sozopol Harbour it covers the time span 3850–3200 cal BC (Draganov 1998).

### *LPAZ Sz-4 (***Quercus–Carpinus betulus–Corylus–Ulmus–Fagus–Triticum***)*

This zone is represented in core 'I'. The pollen record shows the characteristics of early Sub-boreal vegetation and is marked by another decline in AP along with re-expansion of cereals and anthropophytic taxa. This change could be considered not only as a succession related to climatic change at the beginning of the Subboreal but also as an indicator of human impact on primeval deciduous forests that involved more significant invasion of *Carpinus betulus* in forest communities. The decrease of AP, mainly of *Quercus*, and the constant presence of *Carpinus orientalis* could be associated with degradation of the mixed-oak forests. Following this, a slight increase of AP is observed despite indicators of human activity. This could be explained by more abundant flowering on the lower branches of trees after some clearance of dense forests. According to Bottema and Woldring (1990) an increase of pollen productivity is possible in such cases.

Conclusions concerning agricultural practice could be drawn from the constant, significant presence of cereals such as *Triticum* and *Hordeum*, and from the occurrence of weeds such as *Centaurea cyanus*. The presence of cultivated cereals indicates human impact, and their significant abundance testifies to the intensity of this impact. According to the palaeoethno-botanical data of Behre (1977), Todorova (1979) and Popova and Bozilova (1998), the main cereals grown along the Bulgarian Black Sea coast during the Bronze Age were *Triticum monococcum*, *Triticum dicoccum*, *Hordeum vulgare*, and *Hordeum vulgare* var. *nudum*. The wide extent of *T. monococcum* during that time was a consequence of its ability to grow on poor soils as well as on very damp soils owing to its well-developed root system.

An increase of secondary anthropogenic indicators such as *Polygonum aviculare*, *Plantago lanceolata*, *Sanguisorba minor*, *Filipendula*, and *Centaurea jacea*-type suggests stockbreeding and enlargement of forest meadows and pastures. According to Ralska-Jasiewiczowa and Van Geel (1998) the presence of pollen of these taxa documents the formation of habitats rich in nitrates. This is confirmed also by the presence of dung indicators such as ascospores of *Sordaria* (Type 55 of NPP) (Van Hoeve and Hendrikse 1998).

The decrease of percentage values of the dino-flagellate cysts *Lingulodinium machaerophorum* and acritarchs *Cymatiospaera globulosa* indicates that after the Transitional Period sea level started to fall making the area around Sozopol Bay habitable again (Fig. 19.9B). The presence of *Typha angustifolia/Sparganium* and Cyperaceae pollen confirms that the Early Bronze Age settlement was constructed on damp soils, and settlers needed to build their dwellings on wooden platforms. Dendrochronological analysis of oak piles from quadrant 'D' and the neighbouring Early Bronze Age settlement of Urdoviza are of great importance (Kuniholm *et al.* 2007). This analysis has shown that mainly oak piles were used. According to Porozhanov (2003) branches of some trees were used for leaf fodder procurement. Archaeological finds from the submerged prehistoric settlements of Sozopol offers the possibility of defining the main characteristics of human activities during the Early Bronze Age, i.e. stockbreeding, use of horses, hunting, and fishing (Angelova and Draganov 2003). Palynological data provide new evidence for the economy of the local tribe around Sozopol showing well-developed agriculture. According to the archaeological chronology, this zone falls within the time span between 3000 and 2800 cal BC (Draganov 1995).

## Conclusions

Previous studies of marine and lacustrine sediments have emphasized the governing role of climate in determining the character of Holocene vegetation on the southern Bulgarian Black Sea coast, dominated by stable mixed-oak forests. The results presented herein provide further evidence for the impact of human activity and sea-level rise in shaping the palaeovegetation of the area.

The study of the submerged prehistoric settlements in Sozopol harbour has provided new evidence about the prehistoric human occupation of the area and has permitted reconstruction of environmental changes and anthropogenic influence on the vegetation. Palynological data reveal two stages of human impact on natural forest vegetation and significant development of agriculture and stockbreeding. *Triticum* and *Hordeum* were the main crops in the area. The low percentages of weeds are connected with the harvesting practice. Micro-charcoal analysis shows that not only felling but also fire was used for clearance of land for agriculture.

AMS radiocarbon determinations provide chronological resolution, dating the cultural periods represented in Sozopol harbour to the final stage of the Late Eneolithic and the second phase of the Early Bronze Age. The decrease in human activity during the intervening period was due to sea-level rise and/or land subsidence.

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