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Ropotamo: an Early Bronze Age pile-dwelling on the Western Black Sea coast

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Abstract: Ropotamo is a multi-period archaeological site located on the southern Bulgarian Black Sea coast, in a small bay where the Ropotamo River flows into the sea. Due to the unique natural habitat, the site has preserved the stratigraphy left by millennia of human activity in the bay. In 2017, underwater excavations were launched as part of the international Black Sea Maritime Archaeology Project (Black Sea MAP). Over the following seasons to 2020, four trenches were excavated. Documentation was primarily done with a multi-camera rig for high-resolution digital photogrammetry, and interdisciplinary analyses were carried out. At depths between 1.5 and 2.0 m below seabed, artefacts from the Early Bronze Age were discovered: pottery, flint, stone, bone tools and wooden piles of structures. Detailed analysis of the stratigraphy shows that when the sea level was *c.* 6 m lower than the present one, a pile-dwelling settlement was established. The structures were raised on posts near or on a calm freshwater environment such as a river or a lagoon. Radiocarbon dates the site to the very end of the fourth millennium BC. The settlement's inhabitants relied more on hunting than husbandry and were forced to make repairs as the sea level rose, until they eventually abandoned the site.

Introduction

In 1921, when digging for a navigable channel connecting two coastal lakes in the area of Varna, the remains of a prehistoric settlement were found below sea level at a depth of between 3.0 and 4.5 m. In the following decades, the number of known similar settlements increased, and to date, we have data on over 20 underwater prehistoric sites along the Bulgarian Black Sea coast (Ivanov 1993; Draganov 1995, 1998). Most of them date to the Late Chalcolithic and Early Bronze Age (fifth–fourth millennia BC) and are concentrated in two zones: north in the waters of Varna and Beloslav Lakes and in coastal marine bays south of Burgas. Although more than a century has passed since the discovery of the first settlement underwater, only a few of these settlements have been researched archaeologically. Therefore, the study of the archaeological site in the bay in front of the mouth of the Ropotamo River (Figure 4.1) deserves particular attention (Dimitrov *et al.* 2020; Ballmer *et al.* in press).

The Ropotamo River is typical for the southern Bulgarian Black Sea coast: small and almost drying up during summer in the upper reaches but, at the same time, wide and navigable year-round in the last 8.5 km for vessels which draw up to 2.5 m. Typical for Ropotamo and other rivers of the Bulgarian coast (for example: Kamchia, Karaagach and Veleka) is that the estuary is blocked by a sand bank, which closes and opens depending on the winds and the amount of rainfall. These characteristics cause the development of a lasting brackish or freshwater marshy area at the mouths of the rivers, the level of which can rise by more than a metre with a strong east wind and heavy rain in the area.

The bay into which the Ropotamo River flows is about one kilometre wide. From the north, it is closed by a semi-submerged rocky reef with a length of about 200 metres, and from the east by a small sandy and pebbly beach. Due to its specific location, orientation and shape, the bay in front of the mouth of the Ropotamo River is one of the best protected natural harbours on the Bulgarian coast (Figures 4.1.3 and 4.1.4). These exceptional conditions for docking, including wintering, combined with access to the rich and diverse natural resources of the hinterland, have been attracting people to this place since very ancient times.

Underwater archaeological research in the bay at the mouth of the Ropotamo River

Surveys 1973–1989

Underwater studies in the bay began in 1973 and continued with several interruptions until 2020. Until 1989, the leader of the excavation was Prof Ivan Karayotov from the Archaeological Museum in Burgas. In 1989, the last archaeological season directed by Prof Karayotov, an archaeological trench was excavated in a small area; under a layer of mixed archaeological materials (mainly ceramics from Antiquity and the Middle Ages) and a dense mussel layer, prehistoric materials were found: wooden piles fixed in the bottom, burned clay plaster fragments, sharded and whole pottery vessels, grinding stones, bones, flint, stone,

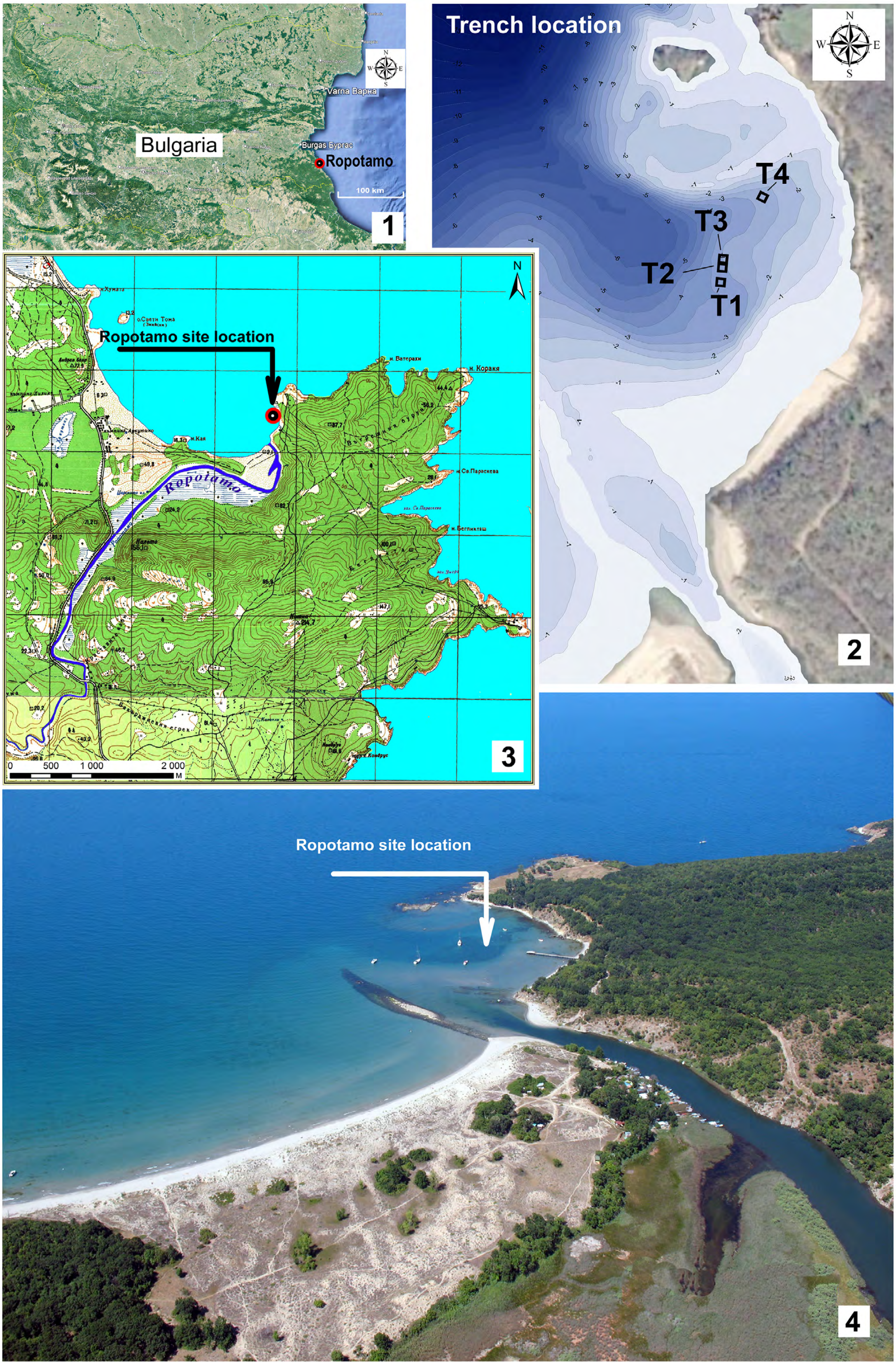


Figure 4.1. Location of the Ropotamo archaeological site. 1, Location of the site on the Western Black Sea coast. 2, Location of the archaeological trenches in 2017–2020 on a bathymetric map. 3, Topographic map of the area of the lower course of the Ropotamo river; a 1:25000 map was used as a base. 4, Arial view from SE of the Ropotamo river mouth and the bay in front of it. Maps compilation by K. Dimitrov.

bone and antler tools. These finds were recorded at a depth of *c*. 2.0 m into the bottom, which means a depth of *c*. 5.5 m below the sea surface. The finds are dated by typology to the first stages of the Early Bronze Age (EBA). Karaytov's studies were interrupted after 1989, but in several publications in the following years, based on numerous finds, he summarised his observations about the studied site, which he defines as a 'sunken harbour' and 'sunken prehistoric settlement' (Karayotov 1990, 1992, 2002).

Surveys 2017–2020

Methodology of excavation and documentation

In the period between 1989 and 2017, archaeological excavations were not conducted, but Ropotamo remained an important site on the map of submerged prehistoric settlements along the Bulgarian Black Sea coast. It remained of great interest because, unlike all other known settlements of this type, this site has not been affected by development or destroyed by large-scale dredging or other anthropogenic activities. This is why in 2017, the prehistoric settlement was selected for underwater archaeological excavations within the framework of the international Black Sea Maritime Archaeology Project. The goal of the excavations was to explore, using modern methodology, the submerged prehistoric settlement in order to shed light on changes in sea level, the changes in the environment and the human response to this evolution. In this way, environmental and archaeological data from Ropotamo would be complementary to the sea-level change data acquired by the Black Sea MAP deep water surveys on the Bulgarian Shelf acquired 2015–2017 (Sturt *et al*. 2018). During the four years of work, two sectors lying 25 m apart were studied; these were labelled T1–T2 (later T2–T3) and T4. In total, an area of about 100 m^2 was studied. The excavation was carried out in layers of about 10 cm or by stratigraphic units. Sediment removal was effected with water suction dredges operated by divers. Each revealed level was documented by underwater digital photogrammetry and photographic and video records. At the conclusion of each of the two sectors (T2–T3 and T4), samples of the profiles were collected to carry out sedimentary, palynological and archaeobotanical analyses. The stratigraphic layers were dated by typological determination of the artefactual and structural material and by radiocarbon dating of wooden and other organic remains (Вагалински *et al*. 2018; Димитров *et al*. 2019, 2020, 2021).

The photogrammetry survey at the site was carried out according to the specifics of the Black Sea and the archaeological site, whose conditions would require some ingenuity. First of all, visibility is usually much lower than in other seas worldwide, even more so for a site located close to a river mouth. For this reason, a rig of several action cameras was used. Every camera was mounted to shoot at a different angle to ensure sufficient overlap of 60–80%, which is essential for a successful photogrammetry model. For the first two seasons at Ropotamo, a specially designed rig to mount five GoPro 7 Black was employed, which gave very good results even in visibility less than 50 cm (Pacheco-Ruiz *et al*. 2018). The drawback was this technique accumulates a very large number of frames, which require a lot of computational power and time to process. Because of this, since 2019, a custom-built frame for just three action cameras was used, which drastically reduced the number of images per survey. This allowed for the completion of daily recordings of the archaeological site and the construction of ready model for the next day.

Surveying a trench in the seabed for photogrammetry is a challenge in itself. It requires sufficient overlap of the images connecting the ground control points or markers; these are fixed on the seabed with the archaeological situation, which can be up to 3 m below seabed. For this, a new survey pattern was applied, one which combines the spiral pattern used by Pacheco-Ruiz *et al*. (2018: 124, Fig. 7 b) and the transversal and longitudinal path presented by Yamafune *et al*. (2016: 12, Fig. 12). To increase local accuracy, 4×1 metre-scale bars or smaller were always placed in the survey area, which minimised the error to 1.5 mm per 1.0 metre. The models were georeferenced by four coded markers, the coordinates of which were taken with a differential global navigational satellite system (GNSS) with a real-time kinematic correction.

Taking precise global coordinates on an underwater site has always been a challenge, especially in deep water, because the signal from the satellites cannot penetrate through the water's surface. Fortunately, the Ropotamo site is at a relatively shallow depth and can be measured by just using a 5 m-long pole to keep the transceiver of the signal above water, a method which has been widely used in recent years (Pacheco-Ruiz *et al*. 2018: 125; Reich *et al*. 2021). Coupled with the millimetric intra-site accuracy noted above, this fixes the position of the trench and every object in the model down to 2 cm of global accuracy.

Since in the Ropotamo project the spatial positioning of the sectors was carried out with a GNSS receiver, the depths below sea level discussed in the actual text are relative to the Baltic geodetic system, which is the standard used in Bulgaria. The real depths, measured on the site with a depth gauge or tape measure, differ from the geodetic ones by up to 20–25 cm. The difference is variable and depends on the tides, which, although small, still exist in the Black Sea.

Before images were loaded into a photogrammetry software, they were first processed with the open-source software RawTherapee. This software provides a fast and easy way to make corrections without affecting the quality of the original image: the white balance has been corrected on all the photos to remove the loss of colours due to the water environment and reduce the resolution to half, as for our purposes, 4k is too much. For the photogrammetry processing, the software Agisoft Metashape was used with a standard workflow (Agisoft LLC 2023), with additional processing steps to clear any interference added by the water environment.

From the photogrammetry model, we export a high-resolution orthomosaic and a digital elevation model. These were used to create a detailed site plan in a vector graphics editor software such as Adobe Illustrator. There the archaeological finds are outlined in standard colours based on their material of manufacture. Stratigraphic changes in the sediments can be visualised with the exact coordinates and depths of any samples taken for further analysis. Furthermore, from the photogrammetry model, we can create animations to better visualise the archaeological situation for the general public.

Stratigraphy of the archaeological site of Ropotamo

In 2017, a complex marine geophysical survey was conducted, and underwater excavations were started within two standard archaeological squares of 5×5 m (T1 and T2). In 2018, the excavation area was increased by a new square of 5×5 m, marked as T3, positioned on the north side of T2. During the excavation in 2018, the excavations in T2 and T3 were connected and shaped as a stratigraphic trench T2–T3. The survey in 2019 and 2020 focusses on square T4, which lies 25 m to the northeast of T3 (Figure 4.1.2).

The stratigraphic observation in T2–T3 and T4 are similar, although not identical, and they present some differences in the thicknesses of individual layers (Figure 4.2). In both sectors, five stratigraphic layers have been established[1]:

- **Layer 1:** At the top,[2] a layer of marine sediments has been studied, which was formed when the bay was used as a harbour. It contains a large number of archaeological materials, mainly ceramics, which were deposited in a recognisable chronological sequence from the Late Archaic to the Late Ottoman period. The chronological and that quantitative analysis of the finds in this layer shows that port in the bay in front of the mouth of the Ropotamo River began to be used with the arrival of the first Greek colonists along the western the Black Sea coast at the end of the seventh century BC, and it experienced prosperity during the Roman and Late Roman time. The discovered amphorae and table vessels are imported and originate from different parts of the Mediterranean. The complexity of the archaeological materials of this layer very well illustrates the periods of economic prosperity and crises on the western coast of the Black Sea.
- **Layer 2:** Under the port materials is a layer of marine sediments in which no archaeological finds are found. The layer is characterised by a large amount of large mussels and oyster shells. This layer represents a cultural hiatus and was accumulated in a period when there were good conditions for mollusc development in the bay: quiet and warm water, rich in nutrients. Chronologically, this layer was accumulated between the third and first millennia BC. Its formation is also associated with a rise in sea level over this long period.
- **Layer 3:** Under the 'hiatus' layer in an environment of marine sediments are found the remains of a settlement from the Early Bronze Age (EBA): fixed wooden piles of building structures oriented vertically or at an angle, pieces of burned clay plaster, pottery, antler, bone, stone and flint tools. The EBA layer also contains faunal remains, most likely related to nutrition.

Archaeological finds and materials from the EBA are found unevenly distributed in this layer from *c*. –4.55 m to *c*. –5.50 m below modern sea level in sector T4 and between *c*. –5.00 m and *c*. –5.65 m in sector T2–T3 (Figure 4.3). Apart from the wooden piles which are still fixed in place, the other finds are not found in situ in the proper sense of this term. The observations (mainly in the trench T4) of the stratigraphic distribution of the individual categories of findings, however, allow for some conclusions concerning the construction of buildings and the stages of their operation and destruction. The buildings are erected as pillar structures with horizontal wooden platforms with a clay coating (Figure 4.4). The vertical wooden piles are carefully sharpened and driven into the terrain by digging and hammering into two layers (4 and 5) on top of which the EBA settlement is built. During the habitation of the settlement, a change in the dynamics of the coastline occurs, and the accumulation of marine sediments between the piles begins. The process is relatively slow; probably at the beginning, it seemed episodic and allowed the inhabitants to carry out repairs and other reinforcement activities to the wooden pile structure. The rise of the sea level and the entry of marine sediments into the boundaries of the settlement continued until the point the site had to be abandoned. Later, the site was completely destroyed and covered by marine sand. It is difficult to estimate the speed of flooding and the absorption of settlement's remains by the sea, but the good preservation of the wooden piles and the archaeological finds suggest the process is relatively fast, and the rise in the sea level of *c*. –5.50 m to *c*. –4.55 m occurs before the wood had time to rot and probably lasts no more than 100–200 years.

- **Layer 4:** Particularly interesting and important for understanding the changes in the environment during the Bronze Age is the layer lying at *c*. –5.6 m to *c*. –5.7 m below modern sea level, on which the settlement is built. In T4, it is a grey silty layer formed in a freshwater environment (Figures 4.4.2 and 4.4.4), and in T2–T3, it is a naturally lithified surface of a coastal sand dune. It is on these levels, which once marked the ancient coastline, people first chose to settle by digging and driving into them the wooden piles for the construction

[1] The terms 'layer' and 'stratigraphic layer' are used here to bring together a stratigraphic unit with similar taphonomy and chronology of findings. This generalization approach is justified by the fact that individual stages of accumulation and formation in the stratigraphic layer often have vague boundaries, since the site Ropatamo was formed by mobile marine sediments.
[2] The description of the stratigraphic layers follows the order of excavation from the surface of the seabed.

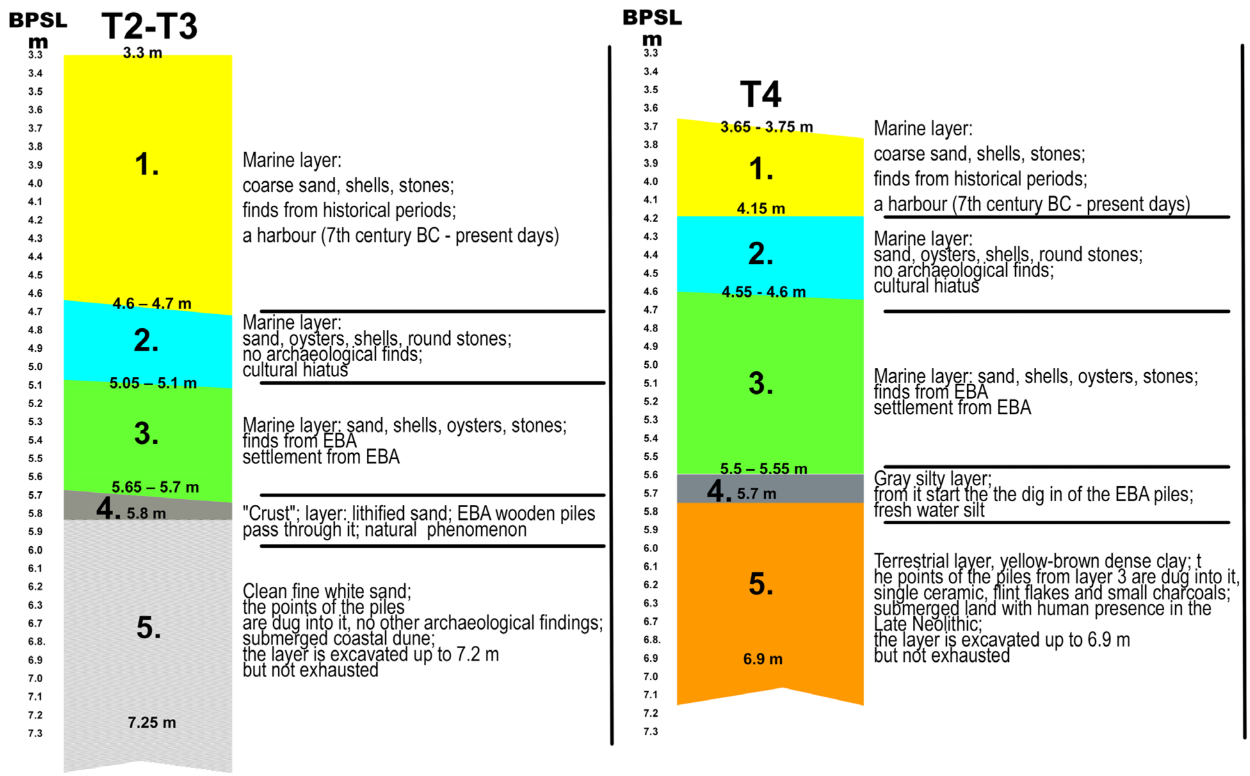


Figure 4.2. Comparative scheme of the stratigraphy in sectors T2–T3 and T4. Compilation and drawing by K. Dimitrov.

of their buildings. Settlement close to the sea level is possible only because the EBA settlement is located not on an open seashore, but on the right bank of the ancient river Ropotamo, not far from its mouth. The place of EBA habitation was probably very similar to the modern landscape which the Ropotamo River has formed along its left bank in the last two hundred metres of its course (Figure 4.1.4).

- **Layer 5:** Below the level of construction in T4 is documented a layer of dense dark yellow, yellow-brown clay, which has a preserved characteristic of a terrestrial soil. In 2020, during a final control trench in this sector, reaching a depth of –6.7 m below modern sea level, several fragments of handmade pottery were found. Their surface is well preserved, and the graphic reconstruction of the forms showed parallels with vessels from the Late Neolithic, the most direct being those from the site Aşağı Pınar 3. Since during the underwater studies of Ropotamo, no archaeological structures have been found which have such an early date, the presence of these single materials from the end of the sixth millennium BC should be explained by the existence in the near vicinity of a still to be located earlier prehistoric settlement, which predates by about 2000 years the occupation of the EBA.

Below the level of BA materials from sector T2–T3 to a depth of –7.9 m from modern sea level is documented a layer of homogeneous white, fine and uniform sand, with no archaeological finds. There are no shells of marine molluscs in this layer, and it is most likely a flooded ancient coastal dune.

Findings

The great majority of prehistoric finds from Ropotamo belong to the EBA layer. The exceptions are the few fragments of ceramics, for which an earlier date has been proposed.

The EBA pottery from Ropotamo is handmade and relatively roughly: there is often a lack of symmetry in the forms, and the clay is coarse with inorganic, crushed shells or fine organic temper. The pottery has a severely eroded surface, which is probably due to poor initial firing, the secondary accidental fire at the destruction of the site and its deposition in a layer of mobile marine sediments. The percentage of whole vessels is relatively small, which distinguishes the collection from Ropotamo from the finds from other submerged settlements on the Bulgarian Black Sea coast. About 50 whole profiles were recorded (Figure 4.5). Most well-preserved vessels are small or medium in size, and large vessels are highly fragmented. Twelve categories of vessels are distinguished: dishes, bowls, jugs, askos, cups, amphorae, pots, containers, lids, ladles and strainers (Figure 4.5). The most common categories of vessels on the site are pots, bowls and jugs. Important for the chronology of the site is the record of askos in the ceramic repertoire (Figures 4.5.19 and 4.5.25), which suggests an earlier date of the complex to the EBA 1 stage.

A small number of the vessels are decorated in a manner typical for the period: stamped, incised, corded, cuts, embossed strips, relief buds and finger pits (Figures 4.5.1–4.5.4, 4.5.8 and 4.5.15). Corded and incised decoration are rare, mainly on the finer vessels (Figures 4.5.1 and 4.5.2),

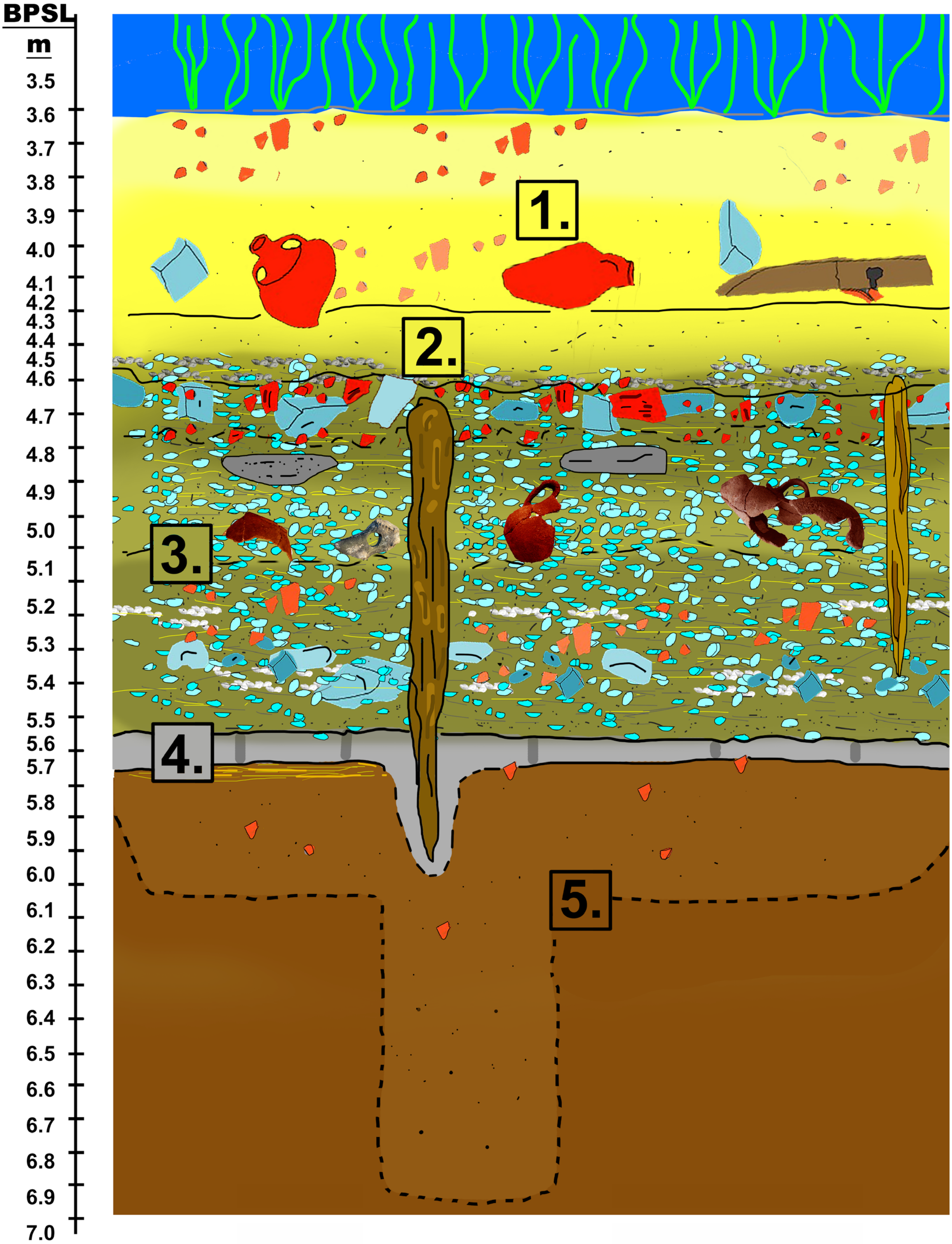


Figure 4.3. Stratigraphic scheme of the archaeological layers in sector T4. Drawing by K. Dimitrov.

but they are important as a chronological indicator for the beginning of EBA 2.

The ceramic complex of the EBA settlement at the mouth of the Ropotamo River finds parallels with the other submerged EBA settlements along the Bulgarian Black Sea coast—those at the Varna Lakes, Burgas, Sozopol, Urdoviza and Atia, the closest being those with the settlement in the harbour of Sozopol. Unfortunately, none of the ceramic complexes of these underwater site is fully published, but based on the known finds, some general conclusions can be drawn.

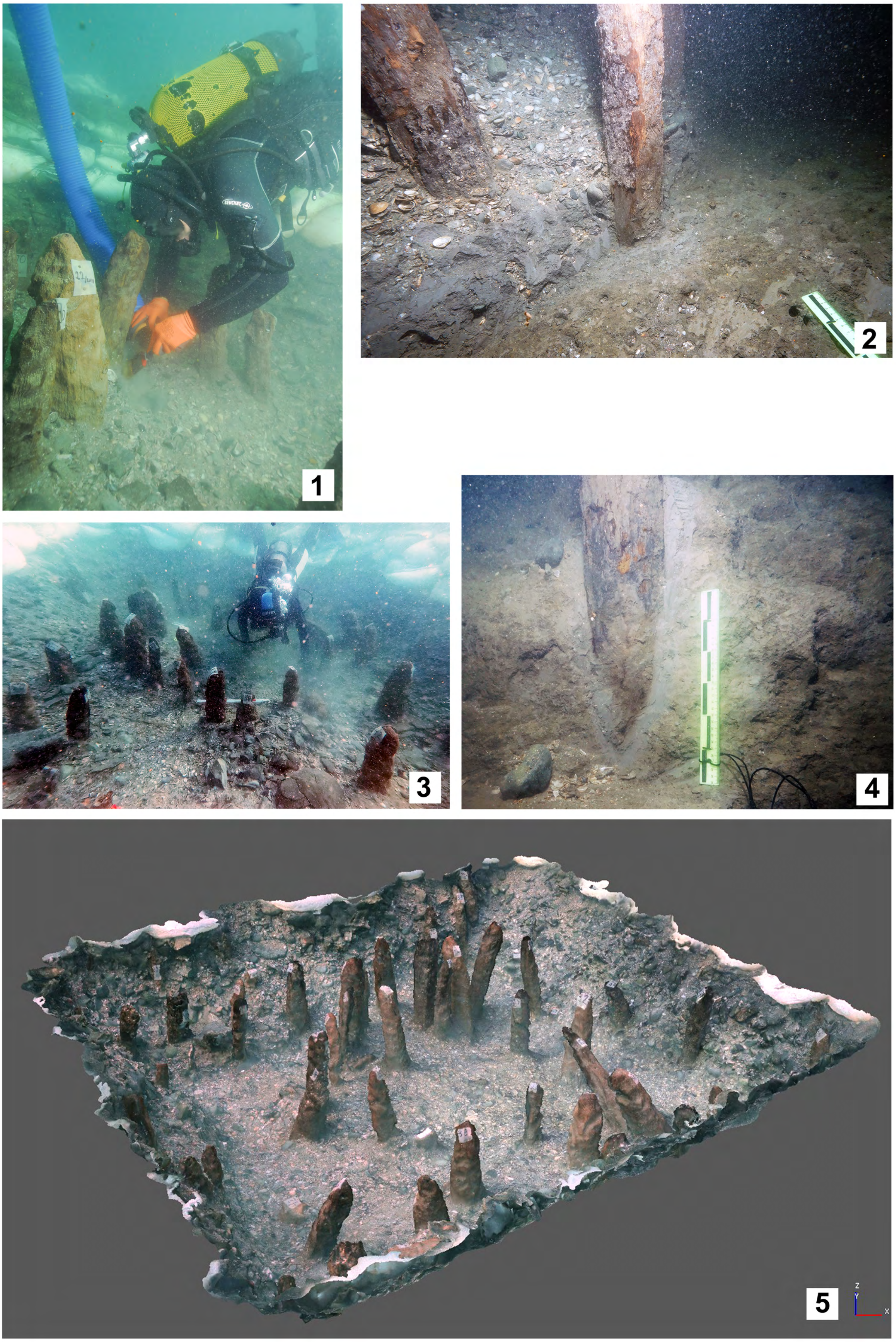


Figure 4.4. Underwater archaeological research in sector T4. 1, Excavation with a waterjet on wooden posts in sector T4. 2–4, Documented stratigraphic situation showing how piles from sector 4 were dug into layers 4 and 5. 5, Wooden piles in sector T4; axonometric view from S. Photos by K. Dimitrov; 3D modelling and axonometric view by P. Georgiev.

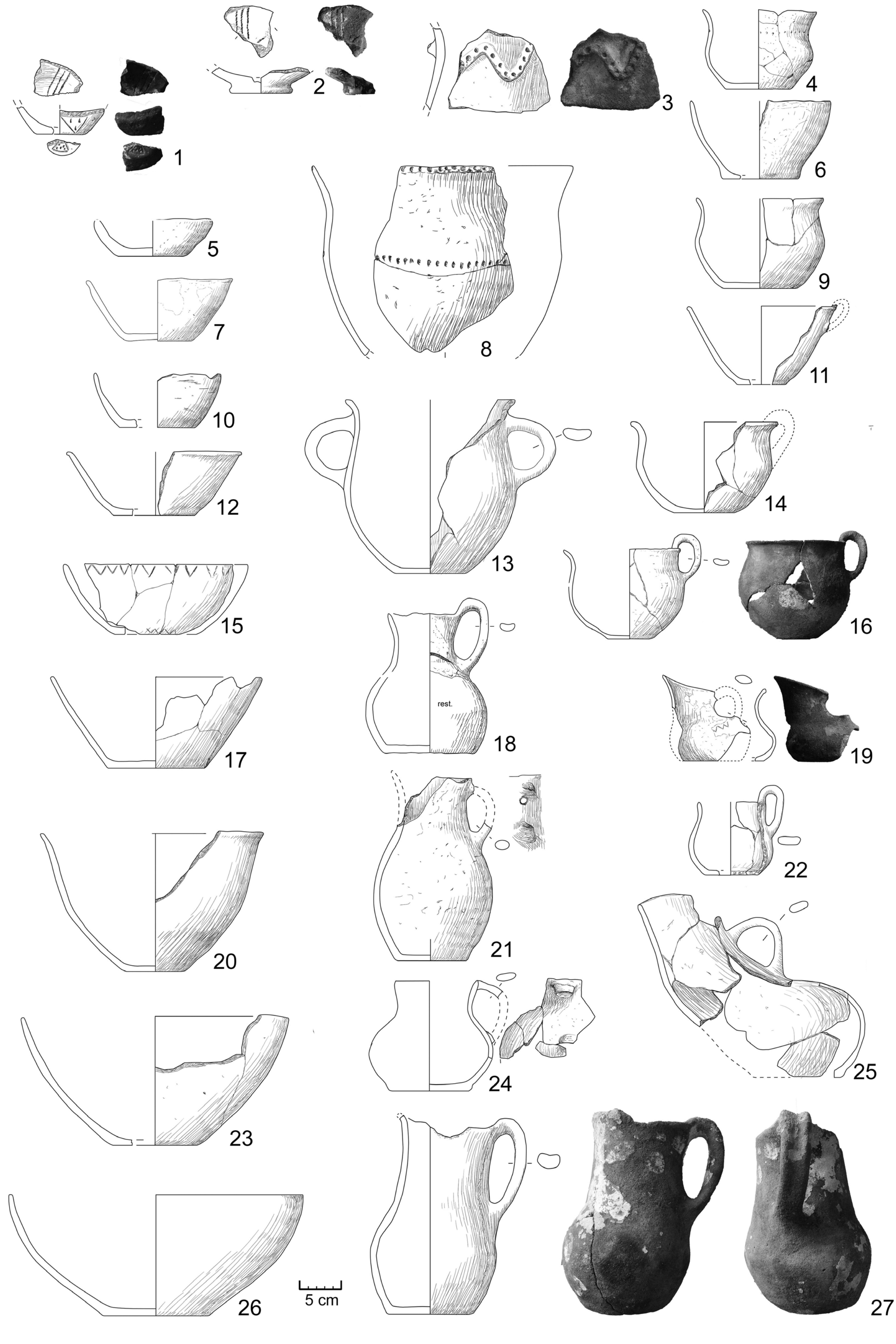


Figure 4.5. Early Bronze Age pottery from the site Ropotamo. Drawings and photos by Hr. Vassileva.

Among the finds from the Varna Lake settlements Ezerovo I, Ezerovo II, Stashimirovo I and Stashimirovo II, almost all types of vessels found in Ropotamo have parallels. Similarities are found in the shape of plates and bows (Маргос and Тончева 1962: Fig. 11; Маргос 1973: Fig. 5/1–5; Иванов 1973: Table V/1–9; Tončeva 1981: Fig. 18/3–8, 19, 20); jugs, cups and askoi (Маргос and Тончева 1962: Fig. 5; Маргос 1973: Fig. 5/11–15, Table VIII/1–3; Иванов 1973: Table IV/3–5; Tončeva 1981: Fig. 7–11); pots and amphorae (Маргос and Тончева 1962: Fig. 6/1–4, 7; Маргос 1973: Table IX/1–4; Иванов 1973: Table V/15–17, 19; Tončeva 1981: Fig 16, 21, 22). The incised and corded decorations from Ropotamo are similar to those found in Ezerovo I (Маргос and Тончева 1962: Fig. 8, 9), Ezerovo II (Tončeva 1981: Fig. 12–14), Stashimirovo I (Маргос 1973: Tables VIII/8–12, IX/8–14) and Strashimirovo II (Иванов 1973: Table V/18, 20). The decoration found in Ezerovo II is dominated by corded and incised ones. Comparing with Ropotamo, a difference in the amount of these types of decoration is clearly discernible. The small amount of corded decoration from Ropotamo indicates this site should be dated earlier than Ezerovo II. On the other hand, there are clear similarities with Ezerovo I in the ceramic shapes, the decoration and probably in the chronology as well.

When the shape and decoration of the ceramics from Ropotamo are compared with the finds from the southern Black Sea coast, parallels can be noted in the forms of jugs, cups and askoi from Burgas (Dimitrov *et al*. 2020: Fig. 7), as can similarities with plates, jugs, cups, pots and amphora found in Atia (Dimitrov *et al*. 2020: Fig. 9).

The ceramic complex from the Kiten–Urdoviza is the best represented in the literature, and this allows the most well-argued typological and chronological comparisons with Ropotamo. Parallels can be found in all types of pottery: plates and bows (Leshtakov 1991: T I, T II; Draganov 1995: Fig. 4/2, 4, 6, 6/1; Angelova and Draganov 2003: Fig. 5/1, 2, 13; Vasileva 2018: Fig. 4/7–12); jugs, cups and askoi (Leshtakov 1991: T VI, T VII/1–6; Angelova and Draganov 2003: Fig. 6/2, 3, 5–13; Vasileva 2018: Fig. 5; Dimitrov *et al*. 2020: Fig. 41/1–8, 10, 11); pots and amphorae(Leshtakov 1991: T III, T IV, T V; Draganov 1995: Fig. 3, 5/15–17, 6/2, 5; Angelova and Draganov 2003: Fig. 5/5–11, 14–17; Vasileva 2018: Fig. 6/6–8; Dimitrov *et al*. 2020: Fig. 42/8). The cord and incised decoration is one of the main characteristic of the ceramic complex from Urdoviza (Leshtakov 1991: T IX; Angelova and Draganov 2003: Fig. 4) as a contrast to the Ropotamo repertoire. This fact points to the likely earlier dating of the Ropotamo settlement.

Parallels with the ceramic finds from Ropotamo are found with those from the submerged settlement in the harbour in Sozopol: plates and bows (Draganov 1998: Fig. 5/2, 3, 9, 10, 14; Vasileva 2018: Fig. 3/2; Dimitrov *et al*. 2020: Fig. 26/4–9); jugs, cups and askoi (Draganov 1998: Fig. 4/12, 5/5–7, 11, 12; Klasnakov and Stefanova 2009: Fig. 1, 2; Vasileva 2018: Fig. 3/3, 4; Dimitrov *et al*. 2020: Fig. 26/2, 27/2–13), pots and amphorae (Draganov 1998: Fig. 5/8; Vasileva 2018: Fig. 3/7, 8; Dimitrov *et al*. 2020: Fig. 26/1, 10–12). Both the types of the vessels and the incised and corded decoration patterns are closest between these two settlement compared to the other submerged sites (Draganov 1998: Fig. 5/1–3, 10, 11).

The relative chronology of the EBA layer of Ropotamo can be related to the transition between EBA 1 and the beginning of EBA 2 in Thrace and synchronised with the some of the land reference sites too: with Ezero in Thrace, at the transition between Ezero A stage and the beginning of Ezero B (XIII-VIII/V construction horizons) (Георгиев *et al*. 1979: 498), with Cernavodă III (Morintz and Roman 1968: 81–98) and Cernavodă II in the Danube Nord East area (Morintz and Roman 1968: 106–115), with Troy I (Blegen *et al*. 1950: 31–199) and Troy II in the Marmara region (Blegen *et al.* 1950: 201–378) and with the Yunatsite XVII-IX horizons in Western Thrace (Николова 1990: 9–16; Катинчаров and Мацанова 1993: 156–157).

The main conclusion from the detailed presentation of the typological pottery parallels with other coastal and inland sites is the Ropotamo pile dwelling represent a specific initial phase of Early Bronze development which nevertheless remains within the traditions of the eastern Balkan Early Bronze cultures of Cernavodă and Ezero type.

The 11 pieces of ceramic fragments in the control trench from sector T4 found in the fifth stratigraphic layer differ from the ceramics described above and have a well-preserved finely worked surface (Figures 4.6.1–4.6.5). From this scarce material can be partially reconstructed three vessel shapes (two cups and one bowl), which find the most direct parallel with finds from Layer 3 of Aşağı Pınar (Parzinger and Schwarzberg 2005: 63, 69, 149, 229). In the periodisation of the Neolithic in Thrace, this means Karanovo III/IV or the beginning of Karanovo IV (after Nikolov 2003), and along the Danube the Vinca B complex. If this preliminary relative and determined only by typology date is confirmed in the future, it means the Ropotamo site has materials from the end of the sixth or the very beginning of the fifth millennium BC, referring to the Late Neolithic (the end of the Karanovo IV period).

The wooden artefacts from the site can be attributed as elements of structures. In total, 83 elements are recorded: 19 in T2–T3 and 64 in T4. Of the total, 75 are posts or piles, five could be categorised as laths and the horizontal beams or joists are just three. On one of the latter elements, a carved joint was recorded. The wood is in different states of preservation, which is most probably linked to its species. The main tree types are oak (*Quercus sp*.) and ash (*Fraxinus sp*.), with a small number of other genera. All the posts have their tips sharpened, and on those in better condition, the traces of tools and partial burning, probably for fire hardening and endurance, could be seen. Their diameter ranges 7–23 cm and their preserved length from 48 cm to 1.40 m. Of all the discovered piles, only

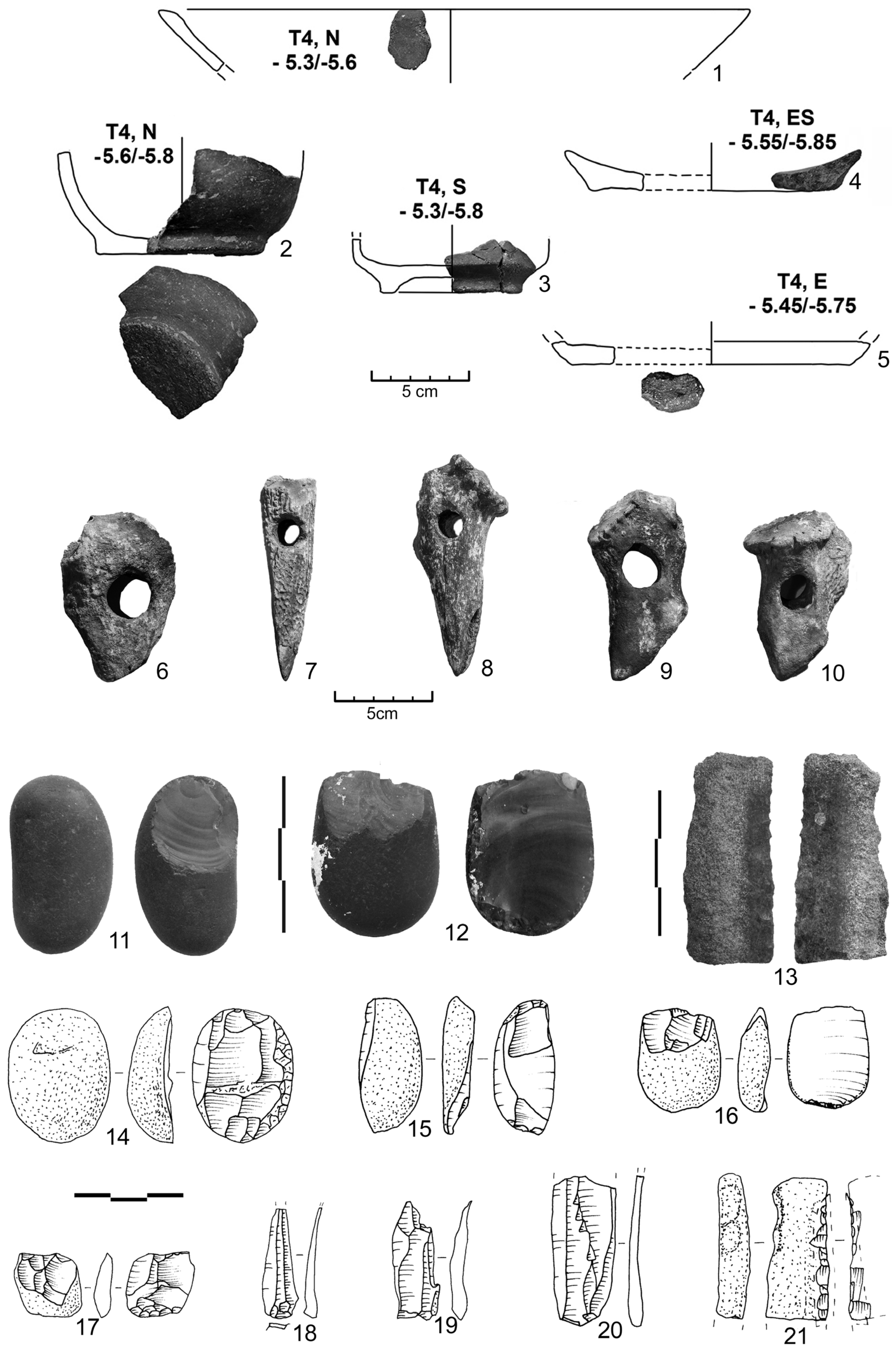


Figure 4.6. Finds from the Roptamo prehistoric site. 1–5, Neolithic pottery from sector T4. 6–10, Antler tools Photographs and drawings by K. Dimitrov. 11–21, Chipped stone artefacts: 11: nodule with unifacial removal; 12, 14–16, 17 and 19: splintered pieces; 18 and 20: blades; 13 and 21: retouched blade used as sickle insert. Photographs and drawings by M. Gurova.

11 had their bark, which could be evidence of intentional stripping. Only two laths have a rectangular cross-section, and several posts could have had one or two of their sides worked. Ten of the wooden piles were intentionally split longitudinally in half, and three were of quarters; the rest were used as a whole trunk.

Most of the piles are found in a vertical position and are from a straight section of the tree. A small number are either curved or slanted. The first is due to the natural curvature of the tree, and the others are the result of the construction with elements at an angle or by a deterioration after abandonment of the settlement.

The collection of prehistoric tools from the Ropotamo site is small and modest, but it contains almost all categories typical of EBA objects: grinding stones, hammers, blades, a socketed antler axe collar, flat stone axes, fragmented, socketed stone hammers, bone awls, *etc*. (Figures 4.6.6–4.6.10). Among the finds, a fragment of a clay metallurgical crucible should be noted. Its presence in the settlement can be associated with the well-known copper deposits of Medni Rid, lying about 12 km northeast from the site.

The knapped stone assemblage from Ropotamo (seasons 2019–2020) is very interesting and comprises 171 artefacts. A proportion represents nodules (most of them black, compact and opaque) with an ovoid-ellipsoidal shape and lengths between 3.0 and 4.8 cm. The nodules were subjected to splintering techniques/bipolar reduction by direct percussion using a hammerstone, with the nodules placed on a stone anvil (Clark 1953; Shott 1999). This technique results in various splintered pieces and rare typical blanks (flakes and blades).

The assemblage contains 34 pseudo-artefacts, four atypical flake cores, 27 nodules with uni- and bifacial removals (Figure 4.6.11), 48 flakes (16 entirely cortical, 24 with partial cortex and eight without cortex) and 18 fragments (10 of flakes and eight undetermined). There are 31 uni- and bipolar splintered pieces, of which 15 were on dimidiated nodules (Figures 4.6.12, 4.6.14–4.6.16); eight on blanks (Figures 4.6.17 and 4.6.19) and eight on fragmented nodules. Separately, there is a small series of blades (four examples), three of which were removed from blade cores (Figures 4.6.18 and 6.20). Apart from splintered pieces, there are five other typological tools, four of which are on blades—three endscrapers and one retouched blade (Figures 4.6.13 and 4.6.21); there is also one backed tool on a kombewa flake.

Use-wear analysis of the blades, the five tools mentioned above and a small series of splintered pieces, allowed the identification of five artefacts used as sickle inserts (Figures 4.6.13 and 4.6.21). There are two tools (an endscraper and a backed tool) with microchipping and undiagnostic polish spots, indicating the cutting of hard material which cannot be identified more precisely.

The presence of standard blades and tools on blades cannot be linked to the application of the splintering technique as part of the on-site *chaîne opératoire*. The blades indicate the importation of blanks of a standard type which can plausibly be linked to the particular domestic needs of the EBA community which inhabited the site.

During the archaeological excavation of the EBA layer in the sectors, T2–T3 and T 4, a collection of a total of 120 animal bones was accumulated. Of these, 87 fragments are defined as species: red deer (NISP 35), cattle (NISP 17), bones of small ruminants (sheep, goat) (NISP 4), domestic and wild boar (NISP 16), roe deer (NISP 1), fox (NISP 1), fallow deer (NISP 7) and fragments of tortoise shells (NISP 2). The ratio of domestic to wild is in favour of wild animals, which accounted for 69% of the total material. Of note, most of the bones and horns belong to red deer, with the remains almost double those of cattle, which is not typical for this period. Deer antlers (noble (red) and fallow deer) were mainly used as raw materials for tools (Figures 4.6.6–4.6.10). For this purpose, antlers already shed in the forest were collected, but those separated from the animal when it was killed were also used.

The cattle's remains are mostly from the upper and lower jaws, but there are also fragments of the pelvis and lower extremities. Only one bone belongs to the auroch (*Bos primigenius*): a distal part of a large tibia. Of the small ruminants, the remains are also very few—mostly jaws and two teeth of individuals in adulthood. Most of the remains of pigs are from wild boar (*Sus scrofa*), while only one jaw and phalanx have been found from a domesticated one. Other single finds are the fragments of bones from horse and fox.

Most of the material in the collection belongs to adult animals over two years, but there are also single fragments of young animals—red deer, wild and domestic pigs, and cattle. All the bones were burned at high temperatures (above 500 C°), most likely along with the layer in which they were found.

The identified species of wild and domestic animals are typical for the period and the area. Red deer and fallow deer have been the most hunted animals since the Late Chalcolithic period (Spassov and Iliev 1994). Fallow deer remains drastically decreased during the Early Bronze Age, but are still found in small numbers at sites in the coastal strip such as Urdoviza (Ribarov 1988; Spassov *et al*. 2018) and Sozopol (Ribarov 1991). The archaeozoological collection from Ropotamo is characterised by a large percentage of wild animals (69% of the total material), which is similar to that of the sunken settlement in the harbour of Sozopol (Ribarov 1988; Spassov *et al*. 2018). The presence of a large number of horse bones from this period in the site of Urdoviza is described by Ribarov and Spasov (Ribarov 1988; Spassov *et al*. 2018), but during the excavations of Ropotamo, only one fragment of a scapula was found, although it is difficult to identify to which species it belongs. According to Spasov, in Urdoviza, 'horses belong to *Equus germanicus*, a broad-hoofed horse and are a domesticated species' (Spassov *et al*. 2018: 14). The bone found at the Ropotamo site may belong to same species, but this cannot be precisely determined.

The faunal material shows that in the Ropotamo region, the climatic conditions in the EBA were similar to those of today, as these wild animals are characteristic of today's habitat. The presence of fallow deer shows a relatively warm and mild climate in the region and mixed forest comprising a mosaic of dense deciduous stands interspersed with open clearings and meadows. The large percentage of bones of wild animals, as well as the age and species composition of the osteological collection of the EBA layer, suggest an economy of the inhabitants in which hunting had a very important place.

Radiocarbon dating

Samples for radiocarbon dating were taken throughout the four seasons of excavation. In total, there are 15 14C dates. One is from a carbonised wheat ear (*Triticum*) found in T2, and all the rest are from vertical wooden piles (Figure 4.7). The latter were selected based on stratigraphy and the number of tree rings, with a preference for piles with more annual rings and the possibility for wiggle-match modelling. Samples were measured at the Scottish Universities Environmental Research Centre AMS Laboratory and calibrated to calendar timescale using the Oxford Radiocarbon Accelerator Unit calibration programme OxCal 4.4 (Bronk Ramsey *et al*. 2001; Dunbar *et al*. 2016).

From sectors T2–T3, there is one sample from pile P 0, four from P 03 and another four from P 07. Accordingly, from sector T4 are two samples from pile P 21 and three from pile P 67. As seen from the result, the dates can be put into three groups: the oldest from pile P 67 which is around 3300–3200 cal BC; the second group from piles P 0, P 03 and P 07 are set around 3100–3000 cal BC, and third and youngest from the wheat ear set around 2900–2800 cal BC. The dates from pile P 21 are uncertain with 45.4% for 3291–3203 cal BC (95.4% probability) and 44.0% for 3066–3013 cal BC (95.4% probability), which means it can fall either to the first or second group of dates.

As for the youngest date from the site (SUERC-108102, wheat ear *Triticum*), we must view it with caution, as the dates from it are too broad (2906–2702 cal BC with 95.4% probability) for a definitive conclusion. Nevertheless, they are coherent with the known general chronology of the site and fit within the EBA.

Based on these results, we can conclude that the excavated section of EBA settlement in Ropotamo could have two building phases: one set around 3300–3200 cal BC and the second around 3100–3000 cal BC. However, the calibration curve for the period 3300–3100 BC is not categorical and allows for the interpretation of the dates in one phase. However, while the 14C dates may represent either two distinct periods of construction or a more or less continuous period, the presence of two phases with a small time gap between them is also suggested by the analysis of the pottery, which shows vessel forms considered diagnostic for the first phase of the EBA (the askoi), as well as a decoration technique (corded ware) associated with the second phase of the EBA.

The discussion here revolves around the dates from pile P 21. If we consider it to be part of the first phase, then we have a situation where sector T4 is from the first phase and sectors T2–T3 are from the second phase. If pile P 21 is part of the second phase, then we have a more complicated situation where in sector T4 are building elements from the first and second phases overlapping each other. It must be pointed out the tip of pile P 21 does not penetrate Layer 4, and pile P 67 is dug in Layer 4 and penetrates deep into Layer 5. After the study of the dendrochronological samples is completed, perhaps this dilemma will be resolved.

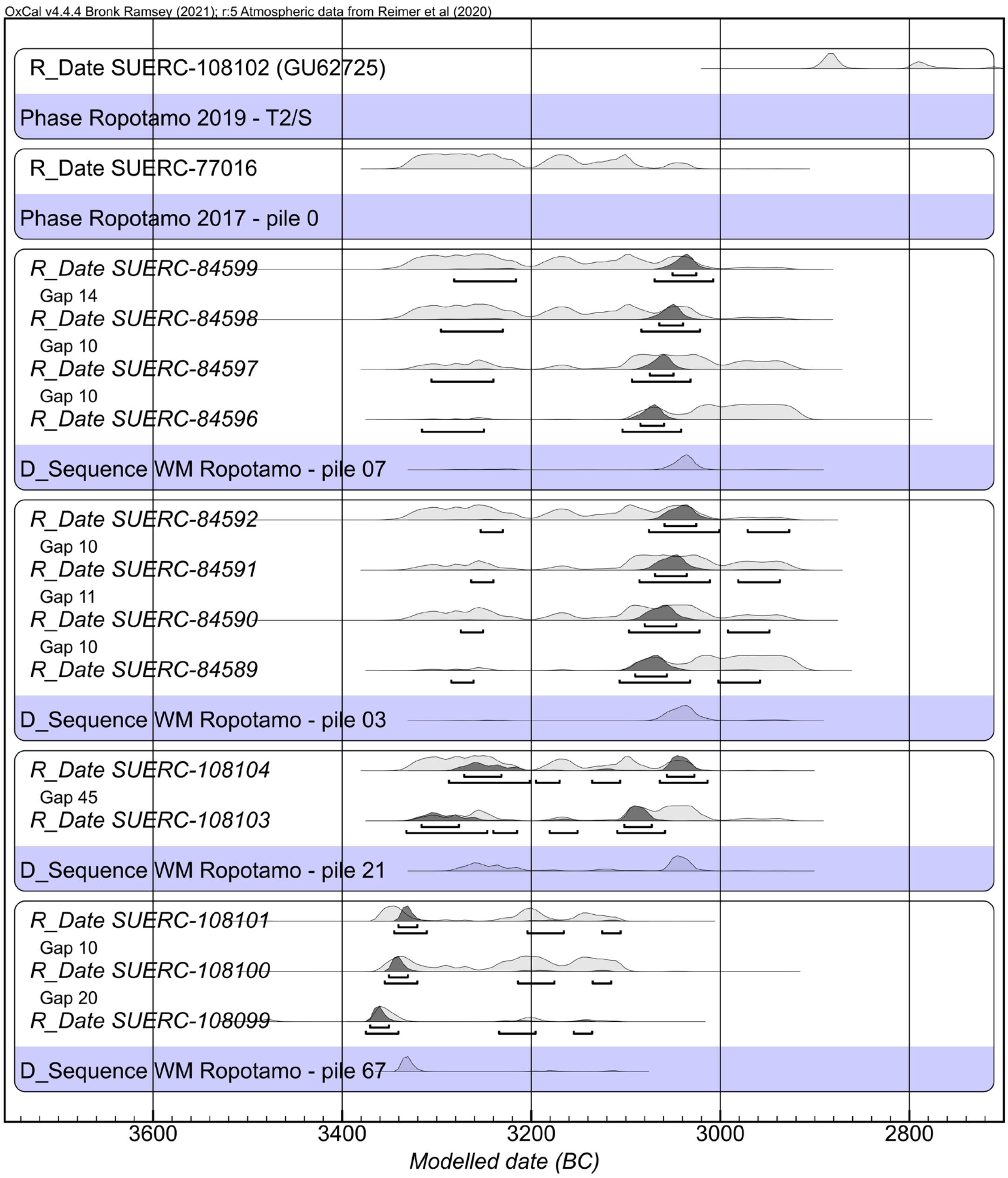
Main results

Underwater archaeological excavations in the bay near the mouth of the Ropotamo River began 50 years ago, making them the longest-term such project in Bulgaria. During these decades, several teams of researchers were sequentially involved, and methodologies of research, excavation and documentation were developed and improved. The final stage of the study took place between 2017 and 2020. It began with a heightened interest and focus on the remains of a settlement from the Early Bronze Age, registered back in 1989, but after four seasons of work, it is clear there is also a contribution to the overall study of the complex underwater archaeological site of Ropotamo. The 2017–2020 study can be considered as a completed stage from which a historical account of people's lives for over 7,000 years can be deduced.

At the beginning of this period, there are modest finds which date back to the end of the Neolithic (the end of the sixth millennium BC). In addition to the fact these materials are the earliest ever found underwater in the Black Sea, they were discovered in a terrestrial layer which today lies below modern sea level.

The well-documented archaeological situations at Ropotamo for the first time provide detailed information about the construction, existence and death of EBA buildings which we find underwater today.

It was discovered that in T4 the wooden piles of the structures were fixed by digging through a grey, sticky alluvial clay layer in order to fix and secure them in the much more stable clay layer beneath it (stratigraphic description Layer 4 and Stratum 5, respectively). The piles are fixed only with grey clay, and there are no marine materials (sand and mussels) in it. This means that during the construction, Layer 4 was free of marine sediment, and this prehistoric surface was directly accessible to humans. These observations and the topographic peculiarities of the area make it possible to describe quite accurately



Site №	Sample ID	BP	±	Archaeological context		Genus	Tree rings	Gap
Rop2017 P0	SUERC-77016	4474	21	T2/2017	Vertical post	Ash *(Fraxinus sp.)*	0-5	
Rop2018 P03	SUERC-84589	4390	34	T3/2018	Oblique post	Ash *(Fraxinus sp.)*	0-1	
Rop2018 P03	SUERC-84590	4437	34	T3/2018	Oblique post	Ash *(Fraxinus sp.)*	10-11	8
Rop2018 P03	SUERC-84591	4422	34	T3/2018	Oblique post	Ash *(Fraxinus sp.)*	21-22	9
Rop2018 P03	SUERC-84592	4452	34	T3/2018	Oblique post	Ash *(Fraxinus sp.)*	31-32	8
Rop2018 P07	SUERC-84596	4386	34	T2/2018	Oblique post	Oriental plane *(Platanus orientalis L.)*	0-1	
Rop2018 P07	SUERC-84597	4423	34	T2/2018	Oblique post	Oriental plane *(Platanus orientalis L.)*	10-11	8
Rop2018 P07	SUERC-84598	4459	34	T2/2018	Oblique post	Oriental plane *(Platanus orientalis L.)*	20-21	8
Rop2018 P07	SUERC-84599	4460	34	T2/2018	Oblique post	Oriental plane *(Platanus orientalis L.)*	34-35	12
Rop2020 P67	SUERC-108099 (GU62722)	4572	23	T4/2019	Oblique post	Oak *(Quercus sp.)*	7-12	
Rop2020 P67	SUERC-108100 (GU62723)	4523	25	T4/2019	Oblique post	Oak *(Quercus sp.)*	28-32	15
Rop2020 P67	SUERC-108101 (GU62724)	4544	23	T4/2019	Oblique post	Oak *(Quercus sp.)*	39-41	6
Rop2020 P21	SUERC-108103 (GU62726)	4436	23	T4/2019	Vertical post	Oak *(Quercus sp.)*	5-6	
Rop2020 P21	SUERC-108104 (GU62727)	4463	23	T4/2019	Vertical post	Oak *(Quercus sp.)*	49-52	42
Rop2019_T2/S	SUERC-108102 (GU62725)	4231	23	T2	Grains	*Triticum*	N/A	N/A

Figure 4.7. 14C dates from the EBA layer of the site and their wiggle matching model. Date compilation by P. Y. Georgiev; calibration with OxCal 4.4 by R. Krauß.

the environment where the settlement from the EBA was constructed: not far from the right bank of the Ropotamo River, in an area outside the direct impact of the sea, probably on periodically flooded terrestrial terrain or in a shallow firth (a long, narrow indentation of the seacoast) of variable level, on which the river had deposited freshwater alluvium.

During the excavation of T 4, it was found that in the time of the existence of the settlement, the space between the piles began to be filled with marine sediments (large mussels, sand and stones), which gradually covered the grey alluvial layer. It was not a steady process and took place in many stages during the continued habitation of the settlement. Evidence of this are whole and fragmented pottery and other archaeological finds situated at different depths in the stratigraphic Layer 3. We believe the appearance of marine sediments in a place they did not exist when the buildings were constructed, was due to a change in the balance between the river level and the sea level which occurred during the habitation of the settlement. The advent of marine sediments to the settlement was probably at first only after the strongest storms. This forced the inhabitants of the settlement to carry out several repairs which have been documented: the installation of additional supporting piles, some of which are fixed only in the marine layer and supporting wooden piles with medium-sized stones. Attempts to preserve the buildings in the face of the advancing sea were clearly not successful because at some point, the inhabitants left. The abandonment of the settlement was probably organised, as in the archaeological finds from the EBA, there is not a single prestigious or cult or other object which we can define as valuable and important for the people of the Bronze Age.

The detailed study of the remains of the settlement from the EBA provides new data to a long-debated question in archaeology: whether the prehistoric settlements underwater along the Black Sea coast were pile dwellings or built on land and later flooded. The stratigraphy of Ropotamo and the distribution of finds and archaeological materials in Layer 3 give several arguments for the pile dwelling construction of the settlement. At the top of this layer are concentrated all the fragments of burned wall and/or floor plaster which have been found. Almost on the same level were found two large grinding stones, as well as several horizontal wooden elements. These categories of finds are associated with the level of habitation, which in this case will be on a platform about one metre above the terrain on which the settlement was built (Layer 4). The second argument for the presence of an elevated construction is the discovery of several relatively large and well-preserved vessels, as well as other finds which lie in the middle part of Layer 3. Our explanation is they mark the intermediate stages of partial filling of the space under the construction before the abandonment of the settlement. The third argument for the pile construction is the location of the settlement itself. It is near the river and on a sedimentary layer in a riparian zone. Knowing well the large amplitudes of the level of the Ropotamo River after heavy rain, often more than one metre, we can easily understand why ancient people would have opted for pile buildings, elevated above the terrain to protect them from periodic flooding.

Archaeological studies in the bay of the Ropotamo River have also contributed to the clarification of the dynamics of changes in the level of the Black Sea over the past 7,000 years. The Neolithic materials from Ropotamo testify that the sea level at the end of the sixth millennium BC is lower than the modern one by significantly more than 5.6 m. Where the coastline was located at this time is not yet possible to say. It can be assumed the Neolithic settlement from which these finds are sourced, as happened in later periods, was located to take advantage of the rich ecological niche which has the resources of the transitional landscape river-sea-land, *i.e.* the late Neolithic coastline was probably no more than a few hundred metres from the present one.

The above interpretation of site stratigraphy and the taphonomy of Layer 3 allows some chronological conclusions, concerning sea level changes in EBA and later. When the settlement was built at the beginning of the Early Bronze Age, about 3100 BC, the sea level was about 5.6 m lower than the modern one. During the habitation, probably for a short period of time, it rose by about 0.5 m, and during the final flooding of the settlement, which probably occurred 3000–2900 BC, the level rose to about 4.5 m lower than today. Sea level rise continued after the final inundation of the settlement, when a shallow, calm and warm bay formed over the remains. This bay becomes an excellent habitat for the oyster colony of Layer 2: oxygenated water with a high light level and with remnant timber structures providing an ideal anchorage for oyster spat. It is only when the timber has finally eroded to seabed level that the deposition of oyster shell ceases. With the extinction of the oyster colony, the seabed of the bay is progressively covered by coarse marine sand, which in the first millennium BC became the bottom of the ancient harbour.

A sea level change of around 1 metre per one to two centuries over the EBA should be regarded as significant and unusual. Whether this phenomenon is local or not will be confirmed by research on other sites along the Bulgarian coast. In this regard, the simple generalisation of the sea level curve from data of the settlement at Ropotamo and their extrapolation to a larger area may be misleading. The unusual amplitude may be a result of the specific location of the site too, which is sensitive to the river-sea interaction and local tectonic causes.

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