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PREHISTORIC MINING AND METALLURGY AT THE SOUTHEAST BULGARIAN BLACK SEA COAST





Raiko Krauss,
Ernst Pernicka,
René Kunze,
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Peter Leshtakov (Eds.)

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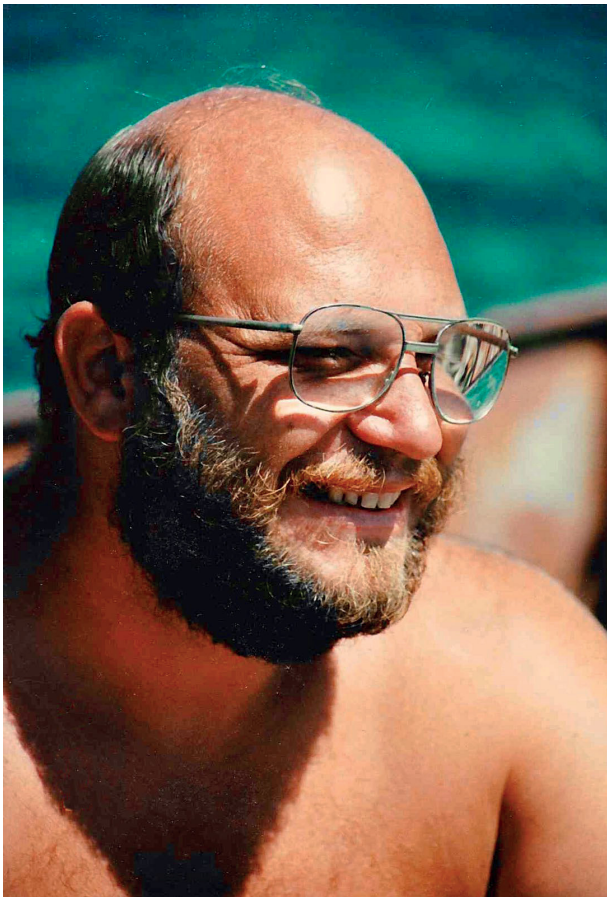
To the memory of

Hristina Angelova 1955–2016
&
Veselin Draganov 1956–2020



Veselin in 1994 during the underwater archeological survey in the port of Sozopol.



Hristina in 2015 after the first season of the Black Sea MAP project.

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Preface

With this volume we present the results of our research on pre-industrial mining in the region along the southern Bulgarian Black Sea coast that were triggered by rescue excavations of several prehistoric settlements with traces of early copper processing. This initiated a thorough archaeometallurgical investigation of the copper ore deposits of Burgas, Rosen and Medni Rid that were mined until recently. In addition, an overview of the archaeological research of the coastal zone of the Black Sea in southern Bulgaria and the now flooded sites in its shore area are included.

In his seminal work on the early metallurgy in Bulgaria Evgeny Chernykh had already suggested that copper originating from the deposits on the southern Bulgarian Black Sea coast was used to manufacture the majority of copper objects found in the rich burials of Varna and Durankulak of the 5th mill. BC. Nevertheless, his exploration and excavations of early copper mining sites concentrated on Ai Bunar near Stara Zagora, because old trenches that were previously known seemed to be more promising for the study of chalcolithic mining, which turned out to be correct. Nevertheless, he pointed out the copper deposits of Rosen, Burgas and Medni Rid in south-eastern Bulgaria as another prospective region for similar studies. Chernykh also performed a large number of chemical analyses of chalcolithic copper objects from Bulgaria but it was difficult to relate the objects to specific deposits using just their elemental composition. Only when lead isotope analysis was introduced to this field of research by Noel Gale in Oxford and the Max-Planck-Institutes for Nuclear Physics in Heidelberg and for Chemistry in Mainz significant progress was achieved in the identification of copper ore sources in the Chalcolithic of south-eastern Europe. Contrary to the then widely accepted assumption that the chalcolithic mine at Rudna Glava in Serbia was a major source for copper, it turned out that instead the very large copper deposits of Bor and Majdanpek in eastern Serbia and Ai Bunar were the major suppliers for copper in the central Balkans. However, in the data yet another source could be identified in the chemical and isotopic composition of a number of objects by highly radiogenic lead isotope ratios and it was suspected that this source may be located in the region of Medni Rid.

In the course of construction works for holiday resorts around the port of Sozopol during the years from 2007 to 2014 numerous new archaeological sites came to light. Most of these prehistoric settlement sites, dating from the Late Neolithic to the Copper Age, have been partially excavated under the direction of Petar Leshtakov, namely Budzaka, the urban stadium in Sozopol and Akladi Cheiri near the town of Chernomorets. The sites of the Late Neolithic, Garmitsa, Chernomorets and Aleppu were surveyed by geophysical methods. Finds of copper ore, jewellery items of copper, copper tools and even cast implements provided the first indications of metallurgical activities in the immediate vicinity of the deposits of Medni Rid. When pyrotechnological installations and numerous ceramic finds with adhering copper slag also appeared at Akladi Cheiri, the importance of these settlements for chalcolithic metallurgy became obvious. As part of our work on the chalcolithic gold in the Varna Museum, we were able to visit the excavation sites for the first time in spring 2011 and subsequently together developed this project as part of SFB 1070 RessourcenKulturen. The results of the four survey campaigns from autumn 2013 to spring 2016 and a number of accompanying studies of project A01 ‘Resources and the Creation of Inequality – Raw Materials and Communication Systems in Prehistoric South-Eastern Europe’ are presented in this volume. Another two field surveys and

geophysical prospections were carried out as part of the project 'Early mining and metallurgy in the eastern part of the Srenogorie metallogenic zone (5th–1st mill. BC)' of the Bulgarian Fund for Scientific Research and the results are included as well.

They are supplemented by a general overview and presentation of recent discoveries in the Black Sea coastal area of the Center for Underwater Archaeology in Sozopol and in the Greek colony Apollonia Pontica.

During the preparation of this volume, Hristina Angelova, the long-standing director of the Center for Underwater Archeology in Sozopol, and Veselin Draganov, a devoted researcher of the submerged prehistoric settlements, passed away. This volume is dedicated to their memory and their contribution to the study and the preservation of the marine underwater and coastal archaeological heritage in Bulgaria.

The editors

0. Introduction

Kalin Dimitrov

Notes on the Landscape and Geology of the Investigated Area South of Burgas

Keywords: geology, Black Sea coast, natural resources, ore deposits, copper ore, ancient mining

Several forested hills, ridges and low mountains dominate the panorama of the seashore south of Burgas. Northmost amongst them Medni Rid (Copper Ridge) stands out – a mountain chain situated a few kilometres parallel to the shore. From north-west to the south-east it extends from Lake Mandra and the southern end of the Burgas Bay to the gorgeous valley of the Ropotamo river which separates it from the south-east of the Maslen Nos (Maslen Cape) massif reaching 4 to 5km into the sea north of the Dyavolska river estuary. To the north-west Medni Rid borders the Rosen Bair upland with which it is connected by a low saddle. The total length of Medni Rid is between 18 and 20km; it is between 3 and 5km in width, and its highest point is Bakarlaka Peak (the name deriving from the Turkish word for copper) 376m above sea level. At first glance this elevation is not quite towering but the chain outline, the steep slopes and the proximity to the sea create in all observers the illusory impression of a much more impressive mountain (*fig. 1*).

The entire Medni Rid/Strandzha coastline has been composed of Upper Cretaceous sediments and rocks of the Cenomanian volcanogenic complex, which contributed to the particularly strong notches of this coast (*fig. 2*). For that reason, north-east of Medni Rid and Rosen Bair from north to south along the coast rocky capes have been formed, known as Chukalya, Atia, Akra, Talasakra, Chervenka, Skamni Peninsula, Budzhaka and Agalina alternating with deep fjord-like bays creating one of the most picturesque seashore landscapes in Bulgaria, an additional element being also the islands of St. Anastasia, St. Cyrik i Yulita (St. Cyricus and Julitta), St. Ivan, St. Petar and St. Toma (*fig. 3*). The main rivers in the region – traced from north to south and from west to east – are the Sredetska, Fakiyska and Izvorska flowing into the Lake Mandra, and the Ropotamo, with its main tributary of the Rosenska river, and the Dyavolska flowing north and south of Maslen Nos respectively. Remarkably, Medni Rid appears to be the main watershed in the region and there are no rivers with a strong and constant runoff east of it. Alongside the geological history and water catchment available, a significant factor for shaping the various relief along the coastline south of Burgas are also vertical movements of the earth crust. Nowadays, they are uneven and negative, showing an average yearly drop between 1,46mm in Burgas and 1,69mm in Dyavolsko Blato south of Primorsko (Мишев et al. 1979, 19 f.).

The Burgas Ore Region

In 1840 Ami Boué (1840) presented initial general data on the geology of the Burgas region. In 1870 Ferdinand Ritter von Hochstetter compiled a geological map of the European territories of the Ottoman Empire including the Burgas ore region in the sub-Balkan eruptive zone of the Upper Cretaceous (*fig. 4*).

In our days the region between Burgas and the Dyavolska river estuary is defined from a geological point of view as the Burgas ore region (Попов 1993a, 4 f.). To understand the genesis and structure of the copper deposits in the Burgas ore region we have to consider more thoroughly



Fig. 1. The Medni Rid mountain chain, view from the sea from the east (Photo: K. Dimitrov).

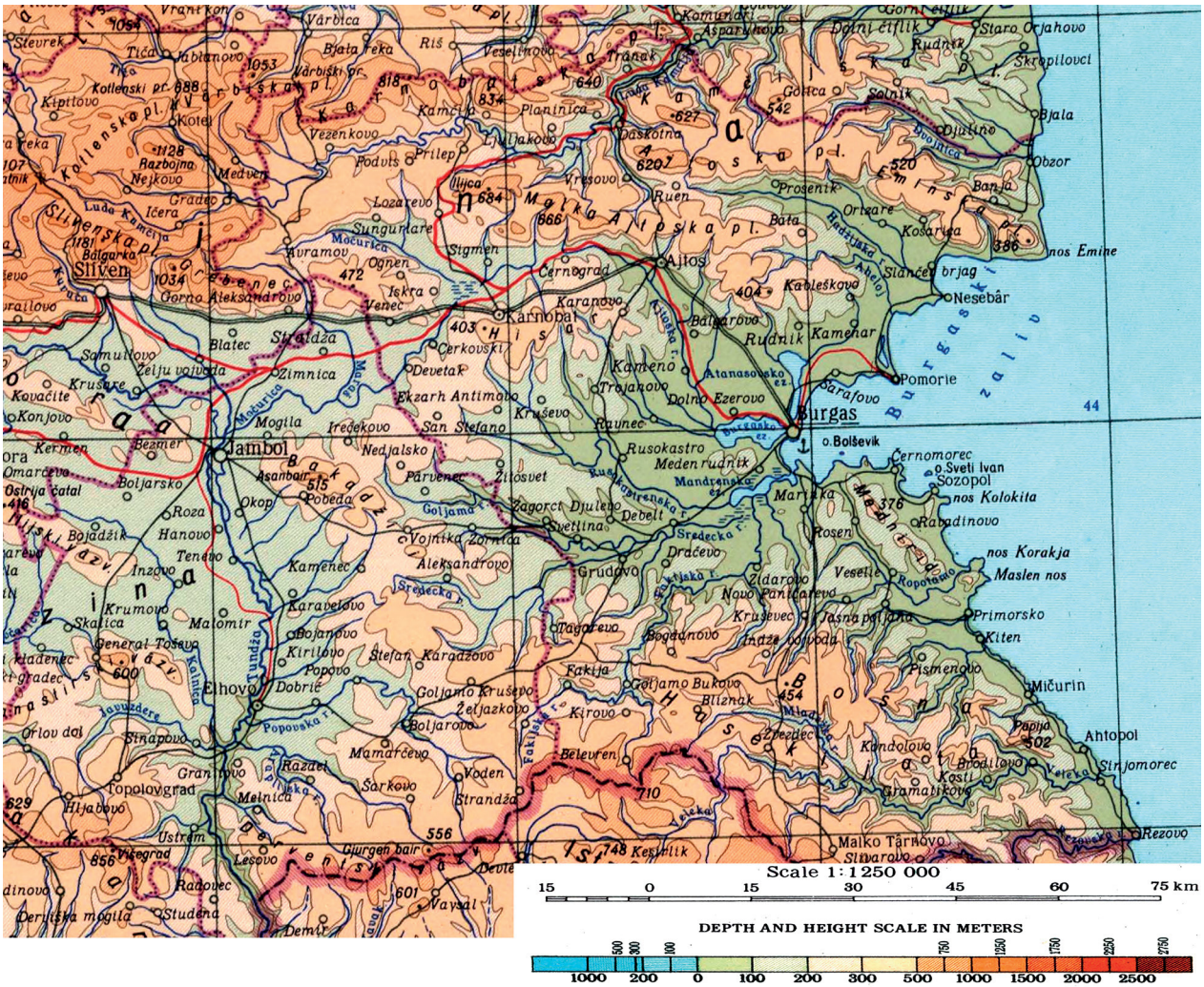

Fig. 2. South-east Bulgaria, a general map of the area, 1:1,250,000.



Fig. 3. Topographic map of the investigated area, Russian army map 1:50,000.



Fig. 4. First modern geological map of the investigated area published in 1870 by Ferdinand Ritter von Hochstetter (von Hochstetter 1870, Taf. 18).

the geological structure of today's territory of Bulgaria as its tectonic partition has been since long recognised as a part of the general structure of the development of the Alpine orogeny (Бончев 1946; 1955; 1971; 1986). According to the recent plate-tectonic theories, the territory of Bulgaria covers part of two large tectonic units – the Moesia platform and the Alpine orogeny. Within the limits of the Alpine orogeny there are two more orogenic systems of a lower order: the Carpathian and Balkan ones. Separate units of a lower rank fall into the scope of both these systems: in the Carpathian one – Kraina and Kula zones, and three zones in the Balkan one – Balkan, Sredna Gora and Morava-Rhodopian zones with their corresponding subunits (Василев et al. 2009; Дабовски/Загорчев 2009, 30) (*fig. 5*).

The Sredna Gora zone is of a complicated construction and has been differentiated as a whole according to the widespread distribution of Upper Cretaceous volcanic-sedimentary sequences and plutonic bodies (Дабовски/Загорчев 2009, 35). The zone is divided into three sectors: western, central and eastern Sredna Gora. The latter sector contains four tectonic units: Sakar, Strandzha, Veleka and eastern Sredna Gora. The Upper Cretaceous magmatism within the eastern Sredna Gora unit is the most intensive and mightiest of all and the mineral wealth of the region is associated with it (Дабовски/Загорчев 2009, 35 f.). In the interaction between the Moesia plate and the Rhodopian massif during the Upper Cretaceous magmatism appeared the large copper deposits in the Sredna Gora. During the Tertiary the lead-zinc mineralisations in the Rhodopian massif were formed.

Scholars divide the metallogenic development of the Sredna Gora zone into pre-alpine and alpine metallogenic epochs as the latter one is connected with the volcano-hydrothermal deposits of massive pyrite, copper-pyrite and copper-pyrite-polymetallic, and copper-pyrite-gold ores (deposits in Elshitsa, Radka, Krasen, Chelopech and Panagyurishte region), copper-porphyry deposits sub-volcano-hydrothermal in origins (in Medet, Asarel, Elatsite, Tsar Assen, Prohorovo and Bardtseto) and plutonogenic hydrothermal vein copper and polymetallic deposits in Varli Bryag, Rosen and Zidarovo (*fig. 6*). The general peculiarity of the latter is their formation among volcanogenic rocks close to the contact of their central intrusive body with volcano-plutonic structures. They have been formed after plutonic introduction and have a clear spatial connection with them: the ore veins fill the radial and concentric faults which cut the volcanic as well as the intrusive rocks (Богданов 1987, 23 f.). We have to note that the Upper Cretaceous magmatism is highly manifested in the eastern area of the Sredna Gora zone, decreasing to the north and west. Thus, they are well corresponding to the vision of differentiation of the Burgas volcanic (and ore) region, including also submerged sectors within the Black Sea aquatory (Попов et al. 1993, 27).

There are more than ten volcano-plutonic centres identified in total within the Burgas ore region: Papiya, Varli Bryag, Rosen, Zidarovo, Tamarinski, Sveti Spas, Voynishki, Yambol, Kabyle, Chokoba, Dzhinovo, Banevo, Dabnitsa and Balgarovo. On the grounds of gravimetric data volcano-plutonic structures are also supposed in the region of Troyanovo, Exarh Antimovo and Zhelyaskovo (*fig. 7*). The volcanoes are arranged on separate lines which mark the location of the main magna-running faults. Thus, to the south the Burgas ore region is separated from the Strandzha one by the Varshilo-Sveti Ilia fault, to the west by the Bakadzhik fault, and to the north by the Zadbalkanski fault. In the centre of the Burgas ore region, the magna-running faults are not to be noticed clearly but probably they are marked by the Rosen, Varli Bryag and Zidarovo volcanic structures and the corresponding ore fields (Попов et al. 1993, 29 f.).

The volcano-plutogenic structures from the central area of the Burgas ore region have an intrusive central core covered by Upper Cretaceous volcanic rocks. They lie over the padding of metamorphic, intrusive and sedimentary rocks: schist and granite, Triassic, Jurassic and Lower Cretaceous terrigenous and carbonate formations. At certain places, the Upper Cretaceous rocks mentioned above have been covered by Tertiary and Quaternary overlay (*fig. 8*).

Volcanism in the Burgas region was most active during the Cenomanian period and continued until the late Campanian period as the intrusive activity accomplished in two stages followed the



Fig. 5. Tectonic scheme of the Alpine orogenic belt on the Balkans and metallogenic map of the south-eastern part of the Balkan peninsula and the neighbouring areas (according to Дабовски/Загорчев 2009, Фиг. 5.1–1).

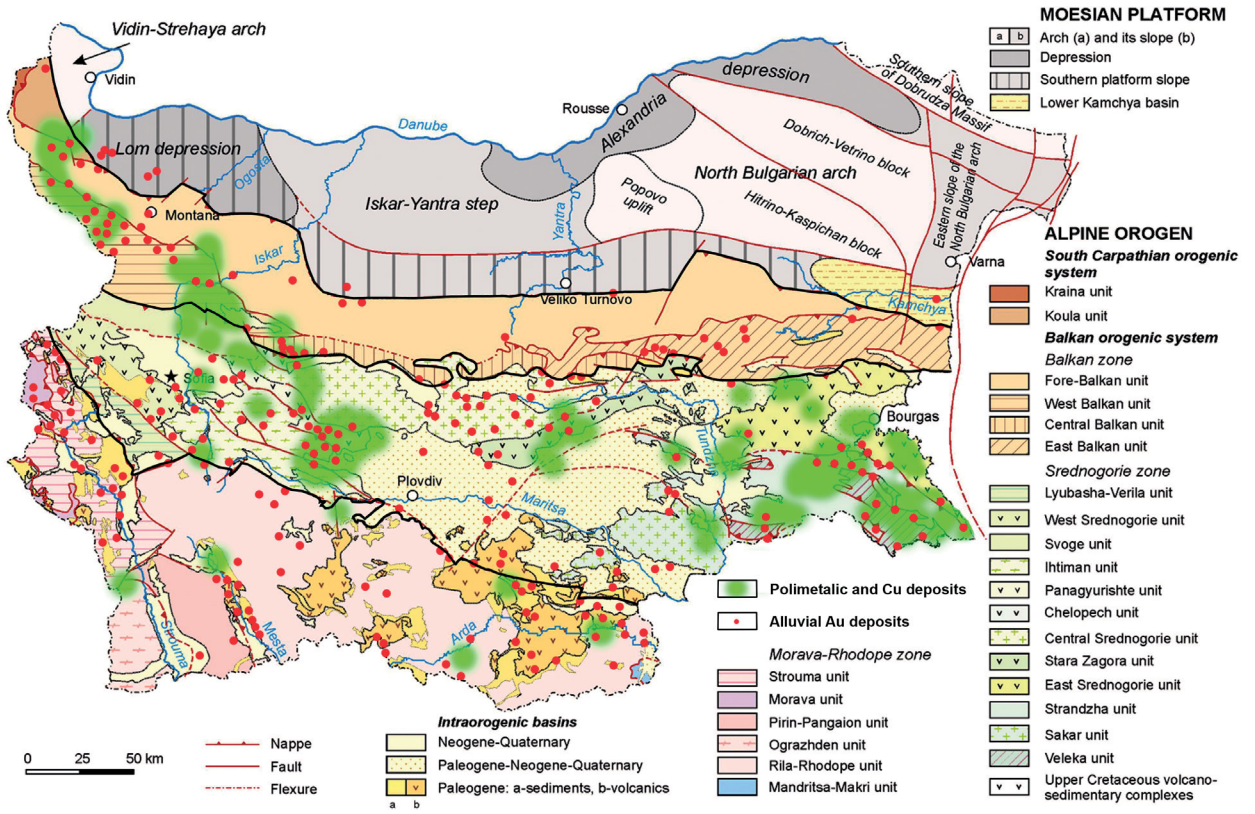

Fig. 6. Tectonic map of Bulgaria on which are indicated main copper, polymetallic and alluvial gold deposits (map according to Дабовски/Загорчев 2009, Фиг. 5.1-8, a compilation of metal deposits data K. Dimitrov).

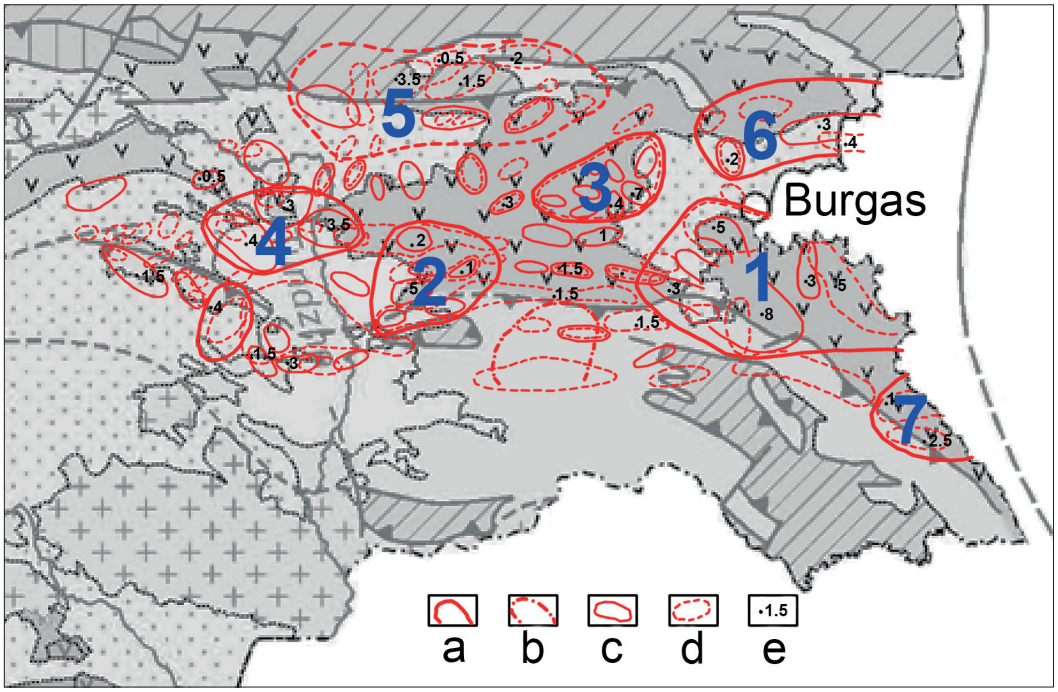

Fig. 7. Scheme of the deep gravity and magnetic anomalies in the Burgas ore area: a) structures with increased density, b) structures with reduced density, c) structures with increased magnetic property, d) bodies with different magnetisation, e) average depth of the bodies in km. The revelled anomalies are indicators for volcanic centres: 1. Burgas centre, 2. Bakadhzik centre, 3. Troyanovo centre, 4. Yambol centre, 5. Trapoklovo centre, 6. Banevo-Trankovski centre, 7. Papiya centre (according to Попов et al. 1993, Фиг. IV-2).

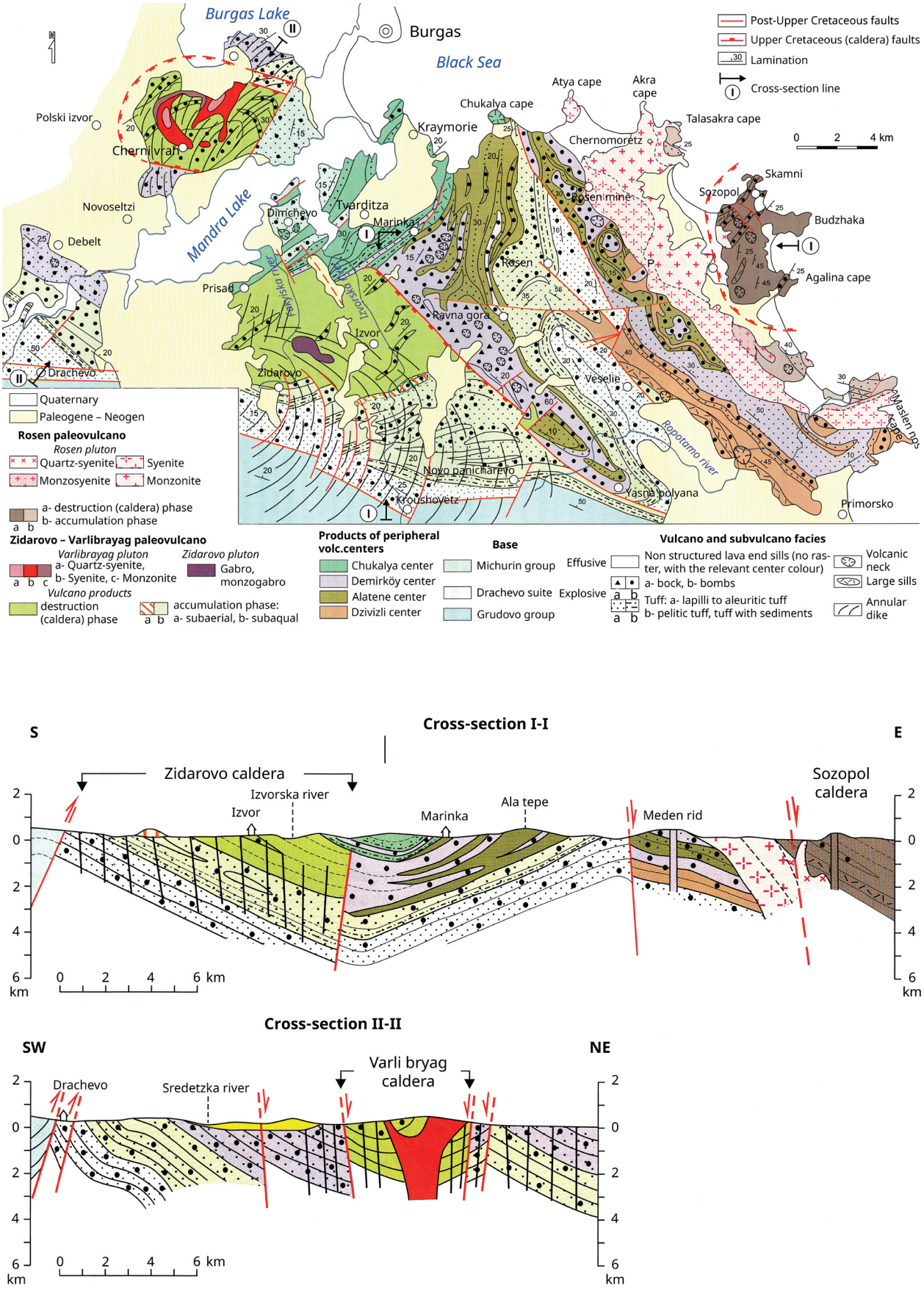

Fig. 8. Schematic map and cross-sections of Rosen, Varli Bryag and Zidarovo paleovulcanos (according to Василев et al. 2009, Фиг. 5.5-115, Фиг. 5.5-116).

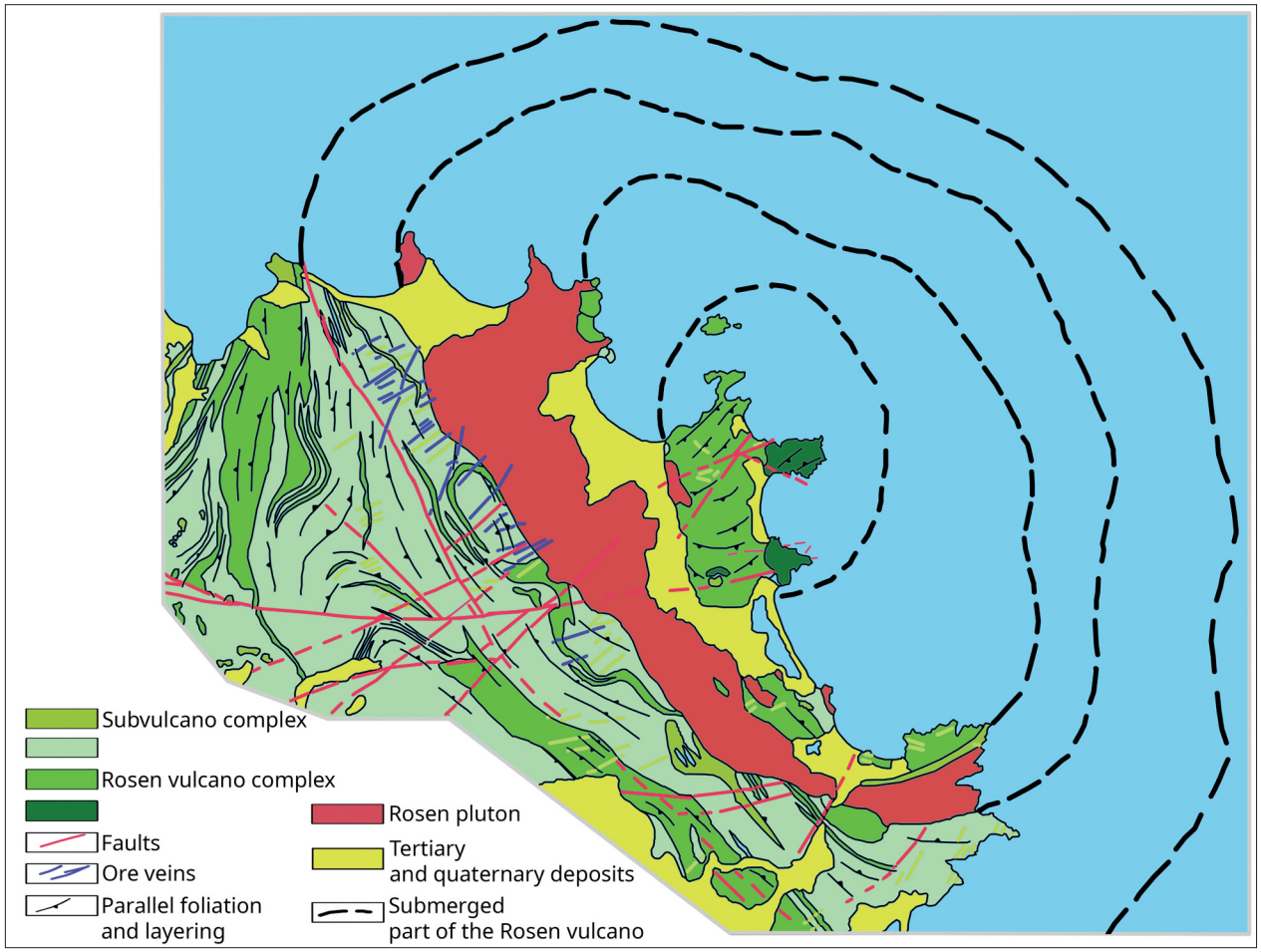

Fig. 9. Rosen ore field: geo-structural map (according to Попов 1993b, Фиг. V-1 and Богданов 1987, Фиг. IV-2).

volcanic one. The formation of the deposits in this group terminated in a stage of complex hydrothermal processes. As a result, ore veins were formed, which filled volcanogenic radial and concentric faults as well as faults emerging afterwards (Богданов 1987, 252–256).

The Rosen Ore Field

The field lies between the Kraymorie residential area and Primorsko town covering mainly Medni Rid; however, a significant sector of it remains beneath the Black Sea, and therefore its entire structure and evolution have not been fully studied (*fig. 9*). The Rosen volcano-plutonic structure determines the state of this ore field. It consists of the Rosen volcano, a complex network of volcano-tectonic faults, the Rosen pluton and the ore veins connected with them.

The Rosen volcano is composed of lava and pyroclastic rocks which form a block with a thickness of 2700 to 3000m. The foundation of the volcano has not been revealed. From the west and south-west, the rocks of the volcano are engaged with the ones of the Zidarovo and Varli Bryag volcanoes. The volcano-tectonic faults emerged in a couple of impulses after the formation of the volcano cupola as a series of sub-volcanic intrusive bodies occurred together with them. In the course of the staged formation of the Rosen pluton, the Sozopol caldera was also shaped (Попов 1993b, 41–43).

The Rosen ore field contains about 40 known copper ore veins exploited industrially, as well as more than 50 other fault structures with hydrothermal mineralisation. All of them are traced over the south-western slope of the Rosen volcano, in the zone of contact with the pluton along Medni Rid. The ore containing faults are developed

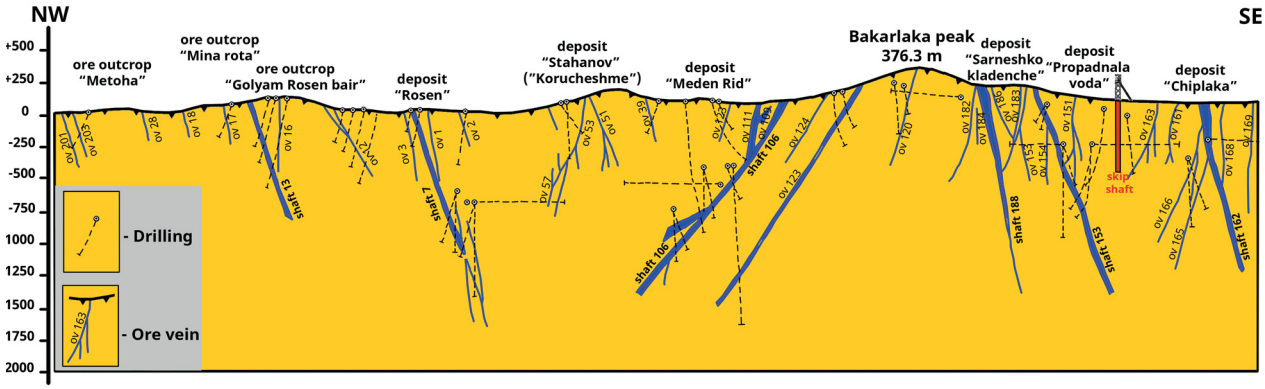

Fig. 10. Cross-section of the Rosen ore field veins (according to Попов 1993b, Фиг. V-2).

among volcanic rocks. The ore veins can be divided into separate groups shaping self-sufficing deposits or ore manifestations from north-west to north-east as follows: Metoha, Minna Rota, Golyam Rosen Bair, Rosen, Korucheshme (Stahanov), Medni Rid, Sarneshko Kladenche, Propadnala Voda, Chiplaka, Lobodovo Kale and Burhamata. In the genesis of the deposit of Rosen, the 'ore zone 7' plays the main role. The ore veins 1, 2 and 3 have a greater industrial significance, while 4, 6 and 8 are of secondary importance (*fig. 10*).

The Varli Bryag Ore Field

This field is located in the south-western outskirts of Burgas, between the city of Burgas and Mandra lakes, in the region of the Karabair heights of Shiloto (208m NN), Kayryaka, Beykonak and St. George (134m NN). The field is composed of Cenomanian volcanic and intrusive rocks as their periphery is covered by thick paleogenic, neogenic and quaternary overlays.

A volcanic and plutonic structure (Karabair) is located in the central sector of the Varli Bryag ore field. It was formed during the Upper Cretaceous and is cut by many volcano-tectonic faults (*fig. 11*).

The Varli Bryag volcano displays a complexly composed accumulative volcanic cone. As a result of breakdown and introduction of the Varli Bryag pluton, the cone has acquired an extended form exposing its central well-eroded zone. The periphery is covered by younger overlays or is flooded by the water of the Mandra and Burgas lakes. The Varli Bryag pluton has been formed as a result of three successive impulses and is located in the central sector of the volcano.

The structural characteristics of the Varli Bryag ore field are determined by volcanic/tectonic faults which lay down the flow of the ore solutions and create favourable conditions for ore deposition. The main fault structure which controls the location of the industrial veins in the Varli Bryag deposit is known as the 'ore zone 13'. It has been traced to a length of about 7km, up to 1200m deep. In total, more than 20 ore veins have been registered in the Varli Bryag ore field, and in general they run in the north-east direction. All of them are typical veins formed by filling. The deposit of Cherni Vrah 1 contains a series of veins known as NN 1, 16, 17 and 18. Number 1 is the most significant and the only one of industrial interest located in the extreme north-west. Its thickness varies from 1,5 to 2m. Its exploitation has continued to a depth of 440m (Попов 1993b, 51–57).

The Zidarovo Ore Field

The ore field is located 15–20km south of Burgas. The region is built of Cenomanian volcanogenic, sedimentary and intrusive rocks. The Zidarovo volcano-plutonic structure has been formed as a result of Upper Cretaceous magma activity within which we can clearly distinguish three successive stages: the effusive (of eruption and outflow) stage, the sub-volcanic stage and the intrusive stage. Three structures correspond to these three stages: the Zidarovo volcano, the Zidarovo ring-like dyke complex and the Zidarovo intrusive. The

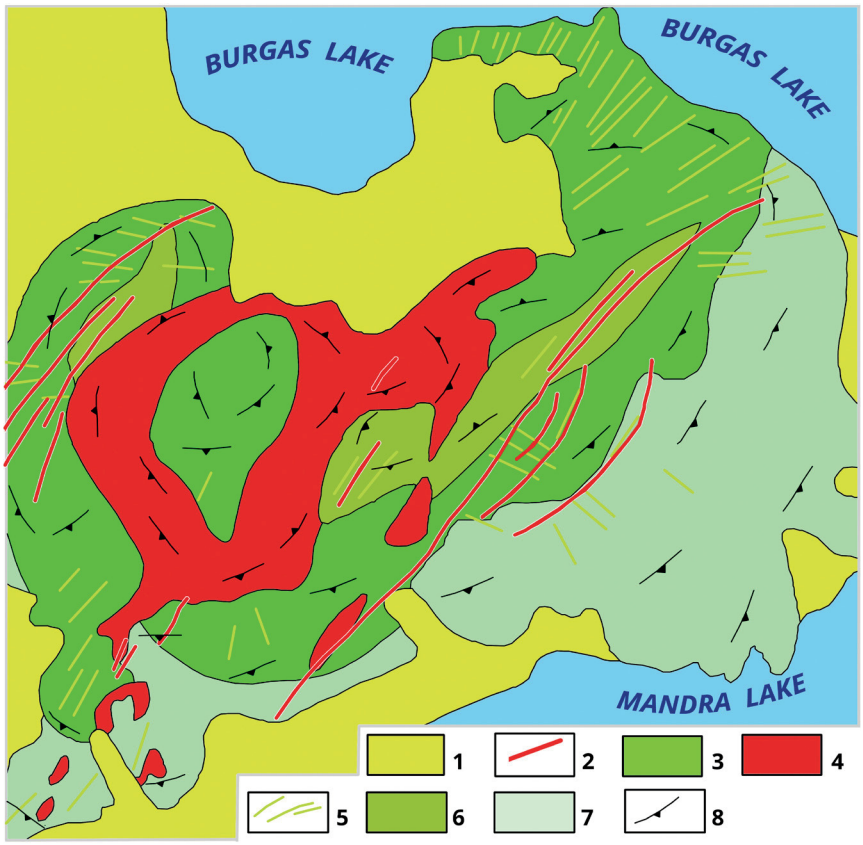

Fig. 11. Varli Bryag ore field: geo-structural map. 1. Tertiary and Quaternary deposits, 2. ore veins and faults, 3. effusive rocks, sub-vulcano facies, 4. Varli Bryag volcano intrusive features, 5. sub-volcano dyke, 6. sub-volcano complex, 7. effusive rocks, 8. parallel foliation and layering (according to Попов 1993b, Фиг. V-9).

volcano is built of volcanogenic rocks about 2000–2500m thick.

More than 50 polymetallic veins with copper and gold as the most valuable metals are known in the Zidarovo ore field formed as a result of post-magma processes leading to a tectonic phenomena and to ahydrothermal activity in the sectors of Krushevets-Yurta, Krushevets, Zidarovo, Izvor and Parlena Kokoshka-Tepeto. As a result of intensive hydrothermal action there, we can observe primary and secondary ore mineralisation. Krushevets-Yurta is better explored and there three ore inserting faults are registered. Ore bodies of a rib-like shape are found there. The length of the particular ore veins is 100–300m (*fig. 12*).

The Mineralogy and Geochemistry of the Rosen, Varli Bryag and Zidarovo Ore Fields

The mineralogy of all the three ore fields is similar and relates to the strong impact of the hydrothermal processes in the course of their formation. The differences observed can be explained by the different temperature during the formation of the ore bodies as well as with the composition of the magma. In the Rosen ore field, the latter was sub-alkaline to alkaline moderately acidic, and in the Varli Bryag field more basic (Богданов1986, 258). The main ore minerals are magnetite, hematite, pyrite, chalcopyrite, native gold, bismuthinite, aikinite, bornite, sphalerite, galena and calcite.

Chalcopyrite/pyrite associations are of industrial significance presented under the form of quartz/sulphide veins. The polymetalic association is also well traced including chalcopyrite, sphalerite and galena accompanied by industrial amounts of gold. Post-ore carbonate minerals and quartz are also presented sustainably.

Bismuth bearing minerals have been registered in all ore fields, and this chemical element is considered to be typical in the ore-formation processes relating to the Upper Cretaceous magmatism in the Eastern Sredna Gora zone. Minerals bearing the elements selenium and tellurium were registered only in Zidarovo and Varli Bryag due to the lower temperatures of the ore-formation processes running there. Only the Rosen

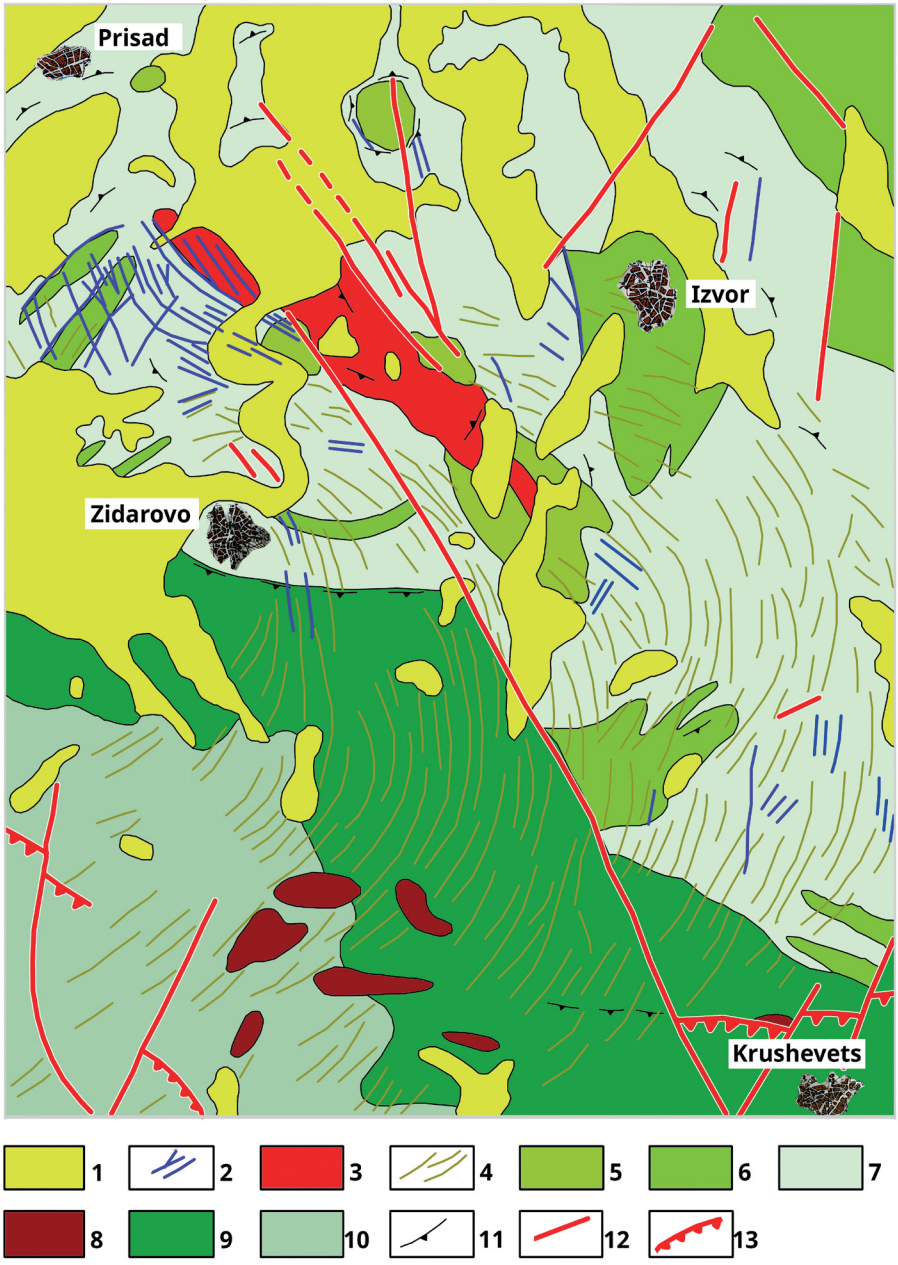

Fig. 12. Zidarovo ore field: geo-structural map. 1. Tertiary and Quaternary deposits, 2. ore veins, 3. Zidarovo volcano intrusive features, 4. sub-volcano dyke, 5. sub-volcano complex, 6. pyroclastic rocks, 7. effusive rocks, sub-vulcano facies, 8. sub-vulcanic monzodiorite, 9. Kazanlak suite pyroclastic rocks, 10. olistostrome deposit, 11. parallel foliation and layering, 12. Faults, 13. Thrust faults (according to Попов 1993b, Фиг. V-11).

ore field contains minerals bearing the elements cobalt, nickel, molybdenum and uranium; this circumstance can be explained with higher temperatures during the formation in this ore field.

Gold has been found in all the three ore fields here discussed. In the Zidarovo ore field, it is in the form of native gold and electrum. The native gold shapes fine ribs in the pyrite. In the Rosen ore field, gold/silver associations have been found in the deposits of Rosen, Stahanov, Medina Rid and Sarneshko Kladenche. They appear together with pyrite, chalcopyrite and carbonate ores in the form of small-grained inclusions as the silver content is high enough to define it as electrum. It has been found out that the amount of gold-containing inclusions decreases in the south-eastern sector of the Rosen ore field being the highest in the deposits of Rosen and Korucheshme (Stahanov) and decreasing in Sarneshko Kladenche. Gold has not been registered in the deposits in the south-eastern sector of the Propadnala Voda and Chiplaka ore fields (Ковачев/Страшимиров 1993, 69–78).

Year	Varli Bryag		Rosen	
	Ore extracted [tons]	Copper content [%]	Ore extracted [tons]	Copper content [%]
1943	662	4.1	-	-
1944	507	4.1	-	-
1945	441	4.1	85	3.54
1946	375	4.1	159	3.53

Table 1. Yield of the orefields in the mining area south of Burgas.

Modern Geological Studies and Industrial Extraction in the Rosen, Varli Bryag and Zidarovo Ore Fields

The modern extraction of copper in the Burgas ore region began in 1882 when a Russian company began the works at the Varli Bryag mine field working there until 1905. The yields of copper were minimal. The mining concession was redeemed in the late 1920s by the Plakalnitsa Mining Joint Stock Company (a branch of the French Plakalnitsa industrial company based in Paris). In 1933 the Plakalnitsa Mining Joint Stock Company also received a concession for the Rosen ore field, but the activity was weak due to the global economic crisis. In 1940 the Plakalnitsa Mining Joint Stock Company sold all its assets (Eliseyna Works, a flotation factory and the concessions for extraction in Rosen and Varli Bryag) to the Bulgarian State which took over the work through Pernik State Mines and State Copper Mines/Burgas branch. The technology employed was rather primitive: the ore was sorted manually on the spot to achieve a copper content above 5%. The concentrate was sent and processed to metallic copper in the factory at Eliseyna Station (Милев et al. 1996, 36 f.). The quantity of extracted ore was rather modest (*table 1*).

In 1947 all private mines and concessions in Bulgaria were nationalised, and an extensive exploration of minerals began as well as the construction of larger industrial plants for their processing. The Varli Bryag ore field was explored in the period from 1947 to 1948 under the leadership of S. Dimitrov who worked out a 1:25,000 scale geological map (Богданов 1987, 291). The initial detailed modern studies of the Rosen ore field were carried out in 1950 and 1951 by Soviet geologists within the Complex Geological Expedition under the leadership of K. V. Makrushin. They compiled the initial modern geological 1:25,000 scale map of the region, which remained at the base of the following mapping.[1] The Bulgarian geological expedition directed by I. Tonev, L. Vasilev and F. Marinov continued the research in the region of Medni Rid from 1951 to 1955. As a result, the genesis and the factors controlling the ore veins in the region were clarified in essence (Богданов 1987, 258 f.). New deposits were discovered and their exploitation began: Medni Rid mine in 1951 and Propadnala Voda mine in 1956 (*table 2*).

The investigation of the Zidarovo ore field began as late as the 1970s. Industrial pyrite ore was established in the deposits of Kanarata and Yurta as their exploitation began in 1978 (Богданов 1987, 310).

According to the archival data available, the following amounts of ore and copper were extracted in total for the time of the industrial exploitation of the deposits in the Burgas region (Милев et al. 1996, 46–49)[2] (*table 2*).

The Burgas ore region and its easternmost sectors of the Varli Bryag, Zidarovo and Rosen ore fields are among the richest copper deposits on the territory of present-day Bulgaria. As early as

1 It seems that the data from the work of this expedition and its reports are the basis from which E. N. Chernih derives information about ancient mining on the territory of Bulgaria, gathered, summarised and discussed in Chapter III of his Горное дело и металургия древнейшей Болгарии (Mining and metallurgy in ancient Bulgaria).

2 The available yield data covers the period after 1943. In 1996 the extraction was terminated due to inefficiency, ecological problems and the economic crisis in Bulgaria.

Deposit	Ore extracted [tons]	Copper content [%]	Ore extracted [tons]
Varli Bryag	1882–1995, with pauses	1.08	85,149
Rosen	1933–1995, with pauses	1.03	77,912
Medni Rid	1951–1996	1.13	46,485
Propadnala Voda	1956–1994	0.95	35,211
Zidarovo	1978–1991	0.87	6,111
Total for the Bourgas ore region until the closure of the enterprises	1943–1995	1.05	250,868

Table 2. Modern mining activities in the region.

during the 19th cent. AD the mineral wealth of the region was discovered, and the industrial mining started on a small scale. In the course of the initial systematic mapping of the region after the Second World War, geologists recorded numerous *rupae*: traces of earlier mining. The recent archaeological surveys of the region, as well as the archaeometric studies of ore samples and archaeological artefacts, allow to trace the earliest mining in this area to the 5th mill. BC.

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Raiko Krauss

The Eastern Balkans in the Neolithic and Chalcolithic

Keywords: Early Metallurgy, Raw Materials, Neolithic, Chalkolithic, eastern Balkans

As part of the Tübingen Collaborative Research Centre SFB 1070 ResourceCultures, the project A01 'Resources and the Creation of Inequality – Raw Materials and Communication Systems in prehistoric south-eastern Europe' pursues the goal of comparatively studying the interaction between resources in the eastern Balkans and the Carpathian Basin over an extended period of time. The choice of the southern Bulgarian Black Sea coast on the one hand and the flatlands of Banat on the other resulted from the very different raw material situations within these two regions. While many raw materials which were important for prehistoric cultures, such as stone raw materials, salt, metal ores and marine resources, were available on the coastal zone of the Black Sea, the Banat commanded no raw materials of any consequence, but it did possess excellent soil and freshwater, requirements for agriculture. The study's point of departure was the question as to whether the resource use of human societies in both regions changed over the course of time and, if so, then if the mechanisms responsible for these might be identified. For the eastern Balkan region, the question should also be pursued as to what factors in the 5th mill. BC led to the development of a socially stratified society which is encountered in the complex settlements and rich burials of this time.

The Early and Middle Neolithic in the Eastern Balkans

The Neolithic settlement of the interior of the Balkan Peninsula originated from the Aegean coastal zone and followed the valleys of the rivers Axios/Vardar, Strymonas/Struma, and Nestos/Mesta running north-south, which might be considered as part of the Mediterranean vegetation zone (Krauss et al. 2017). Only after the end of a period with marked changes in climate, often described as Rapid Climate Change (RCC) of the 8.2k calBC event (Weninger et al. 2005), it became possible for the Early Neolithic farmers with their winter-sensitive economic means to advance into areas north of the Aegean. Accordingly, this expansion initially occurred only along these three river valleys with their comparatively mild microclimates. The considerable challenge, which the continental winter of the Balkans must have posed for the overwintering of herds and seeds could explain, why only sheltered locations were chosen for settlements. In this manner, the early farmers and pastoralists quickly reached the region of the Southern Morava in central Serbia and the lowlands on the lower course of the Danube, while, as far as is currently known, avoiding the countryside of Thrace and the southern mountain regions of the western Balkans to the right and left respectively. The Neolithic settlements, for example at Dzhulyunitsa and Koprivets in northern Bulgaria, appear already in the final decades of the 61st cent. BC (Krauß et al. 2014a; Marinova/Krauß 2014) and are contemporary with the earliest sites in western Bulgaria along the Strymonas/Struma route such as Galabnik, Chavdar, and Kovachevo (Görsdorf/Bojadžiev 1996; Bojadžiev 2007). By contrast, the earliest Neolithic sites in Thrace are known from the 59th cent. BC, comprising the earliest settlements of Stara Zagora county hospital, Karanovo, and Azmak (Görsdorf/Bojadžiev 1996). For historical reasons the Early Neolithic in the eastern Balkans is named after the most important site located at the foot of the



Fig. 1. Tools made out of blades of so-called 'Balkan Flint' from the Early Neolithic settlement of Yabalkovo (Gurova 2012, fig. 3).

Anti-Balkans (Srednogorie), Karanovo I, which corresponds to the Starčevo I level in Serbia. Accordingly, the earlier find horizon at the Lower Danube can be considered as 'Pre-Karanovo', even if there is as yet no indication of a well-defined cultural level. Far better explored is the Early Neolithic find horizon throughout the central and eastern Balkan region in the 59th cent. BC, but particularly early in the Southern Morava valley and northern Bulgaria. In academic literature, the relevant cultural groups were described already very early and named after two sites as Starčevo and Karanovo, although both do not feature the earliest expressions of the Neolithic.

For the eastern Balkan region, the periodisation of the Neolithic according to the stratigraphy of the settlement mound of Karanovo is nevertheless acceptable, as it displays a largely continuous sequence from its initial settlement in the 59th cent. BC down to the 43rd cent. BC. The chronological system of Karanovo I to VII suggested by Georgiev (1961) was further refined, and its essential features are still valid until today (see Krauß 2008). Including the results of more recent excavations undertaken since 1984 (Hiller/Nikolov 2002, with further literature), the levels Karanovo (K) I and K II now stand for the Early Neolithic, K II/III and K III for the Middle Neolithic, and K III/IV and

K IV for the Late Neolithic, with K V for the Early Chalcolithic and K VI for the Late Chalcolithic. Later the settlement was abandoned and only during Early Bronze Age brief settlement activities on the mound were detected, which may be considered as K VII. For the Neolithic period, the find horizons defined with reference to the ceramic material are, however, of extremely variable regional significance. While K I, K II, and K VI each describe cultural groups which were distributed more or less across the entire Eastern Balkans, the pottery from horizons K II/III, K III, K III/IV, and K V respectively is only characteristic for the Thracian Plain or even just some parts thereof (Krauß 2008).

In addition to agriculture and animal husbandry, the economic basis during the Neolithic consisted of intensive use of the local flint deposits, which, to some extent, acquired superregional importance for all in south-eastern Europe. In particular, a caramel-coloured type of flint with white spots, the so-called 'Balkan Flint', of which some deposits might be localised in northern Bulgaria (Biaggi/Starnini 2010; Gurova 2012), was widely distributed over many Early Neolithic settlements from the northern Aegean up to the Banat (*fig. 1*). Until the Middle Neolithic, from the 55th to 54th cent. BC, communities, have a strong regional focus and, according to the find spectrum, entertain only a few long-distance contacts beyond exchange relationships between immediately neighbouring communities. While at the very beginning of Neolithic settlements in the Balkan region strong contacts with the Aegean (from where they originated) are recognisable based on the highly uniform find material in both regions, these contacts seem to have decreased over time or have indeed been entirely abandoned. This is indicated, for example, by an increasing regionalisation of the ceramic production.

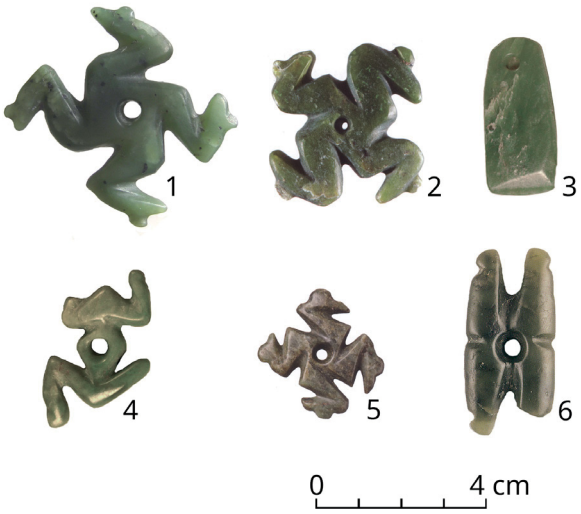

Fig. 2. Early Neolithic jewellery pendants made of green stones. 1 Kardzhali, 2 Mursalevo, 3–4 Ovcharovo-Gorata, 5 Sofia-Slatina, 6 Ruse (after Jacob 2004, Kat.Nr. 16; Krauß 2014, 168 f.; Николов et al. 2016a; 2016b).

The Late Neolithic in the Eastern Balkans

A notable transformation occurs in the Late Neolithic, approximately beginning with the 53rd cent. BC. For the first time since the Early Neolithic, uniform vessel types such as the carinated bowl appear again over wide areas. In the central Balkans, an exuberant practice of paint decoration of vessels develops, while in the eastern Balkans an equally opulent tradition of plastic decoration with cannelures and punctured or scratched patterns predominate. Discoveries of small oxen figurines with perforated snouts suggest that in this period animals were led 'by the nose' for the first time in order to be used for labour purposes (Krauß 2016). A figurine of a bull with a person sitting on top from the site of Kapitan Andreevo (Nikolov 2015) might indeed be the earliest presently known representation of a rider. Green minerals enjoyed particular popularity, having been worked into jewellery such as amulets, pearls, and the trimming of garments by means of cutting and boring since the Early Neolithic (*fig. 2*). Also, small-sized copper tools were smelted already around 5000 BC in the central Balkans (Radivojević et al. 2010). The contemporary sites of Akladi Cheiri and Budzhaka, both excavated under the supervision of Petar Leshtakov are presented for the first time in detail in this volume. At Akladi Cheiri, both the mechanical working of the copper mineral malachite into items of jewellery and smelting of ore could be proven although the exact dating to the Late Neolithic is somewhat uncertain as the earliest settlement layer was disturbed in many places by later cuts from the overlying Chalcolithic settlement.

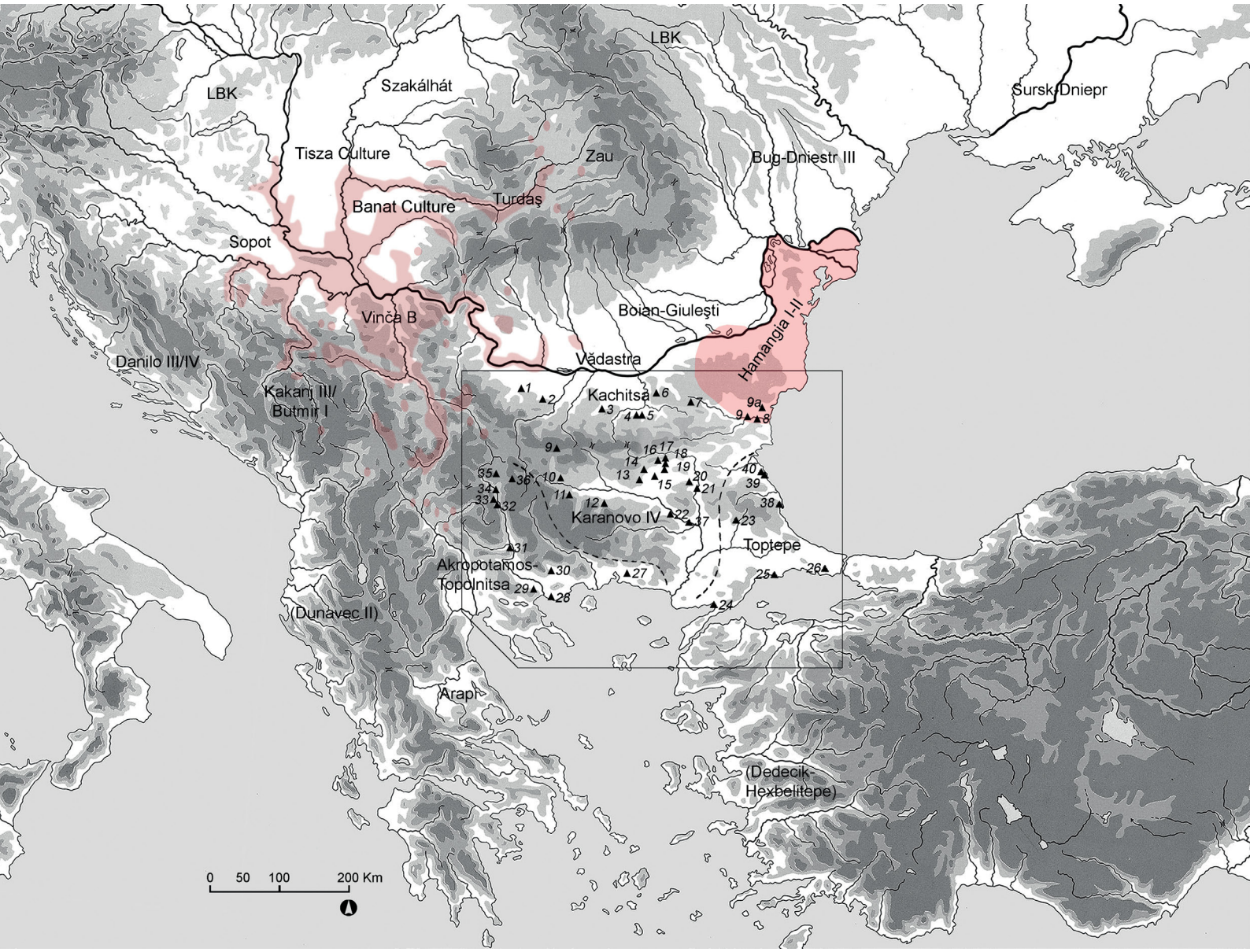

Fig. 3. Map of Late Neolithic settlements in the eastern Balkans (53rd–50th cent. BC). Karanovo IV and Kachitsa-Groups: 1 Gradeshnitsa, 2 Tlachene, 3 Devetaki, 4 Kachitsa, 5 Samovodene, 6 Koprivets, 7 Podgorica, 8 Usoe, 9 Sava, 9a Provadiya, 10 Chelopech, 11 Kapitan Dimitrievo, 12 Muldava, 13 Kaloyanovets, 14 Stara Zagora, 15 Sarnevo, 16 Karanovo, 17 Korten, 18 Nova Zagora, 19 Ezero, 20 Drama, 21 Elhovo, 22 Lyubimets. Toptepe-Group: 23 Aşağı Pınar, 24 Hoca Çeşme, 25 Toptepe, 26 Yarımburgaz, 37 Kapitan Andreevo, 38 Budzhaka, 39 Primorsko, 40 Sozopol. Akropotamos-Topolnitsa-Group: 27 Paradimi, 28 Akropotamos, 29 Galepsos, 30 Sitagroi, 31 Topolnitsa, 32 Balgarchevo, 33 Mursalevo, 34 Slatino, 35 Proboj, 36 Sapareva Banya (after Nikolov 2002; Parzinger 2005; Чохаджиев 2007 and Тодорова/Вайсов 1993 with additions).

Within the K IV horizon, in the eastern extreme of Thrace, a group of finds with typical pottery shapes can be identified which is named after Toptepe in the Turkish part of Thrace (Özdoğan 1999). It is primarily characterised by single-handled jugs with high, cylindrical necks and bulgy lower parts. The decoration of these vessels can be clearly distinguished from the decorative technologies otherwise common in the K IV period. Here, only after firing, linear motifs were scratched into the vessels' surface with a pointed object. The distribution of the Toptepe pottery encompasses all of Turkish Thrace, but in Bulgaria it is restricted to the narrow littoral of the Black Sea, extending approximately up to the Balkan range. The distribution area of Toptepe ceramics in Bulgaria is thus limited to the region between the Strandzha mountains and the modern coastline of

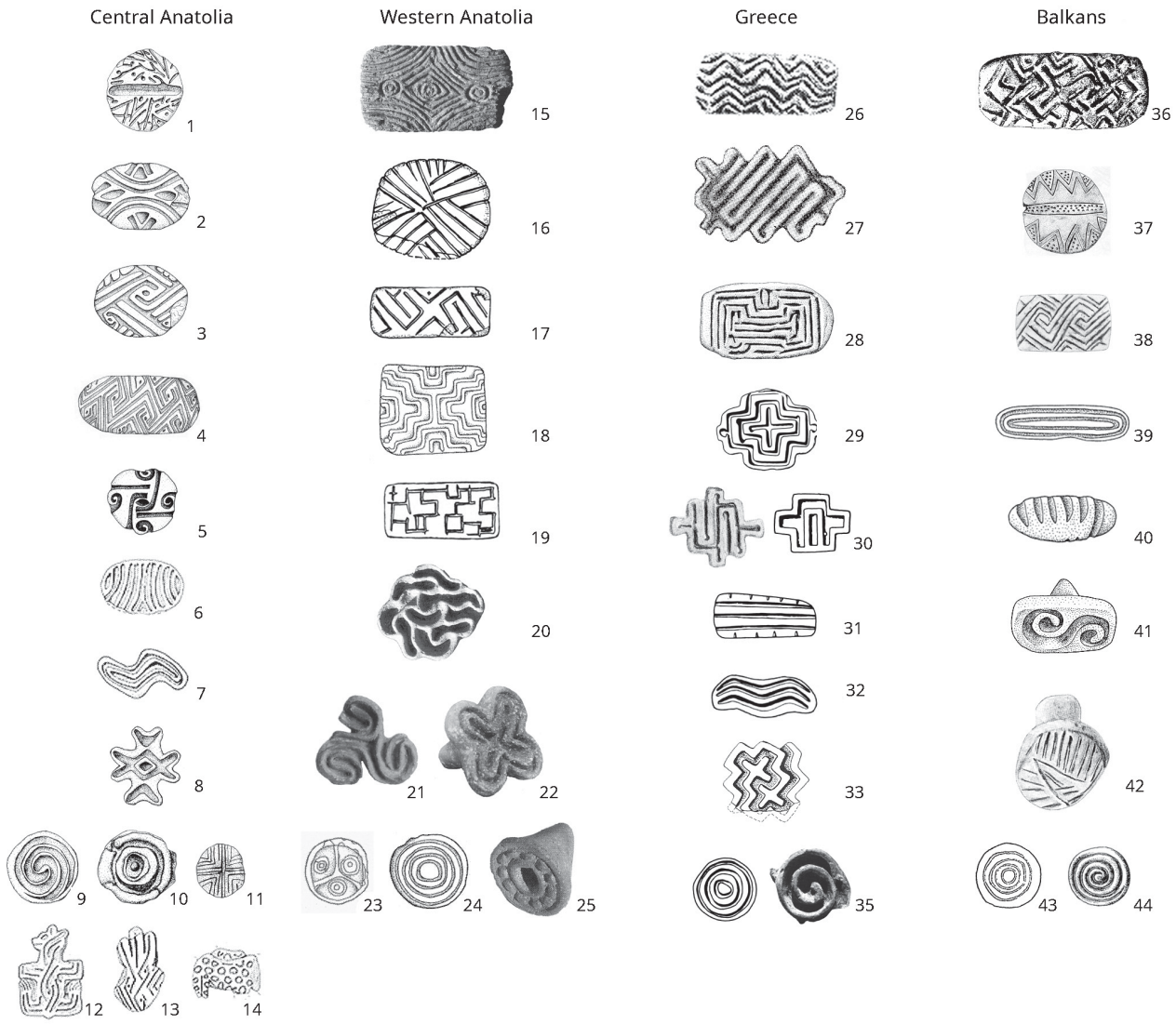

Fig. 4. Comparison of Neolithic stamp motives (Lichter 2011, fig. 2).

the Black Sea (*fig. 3*). The material from sites north of the Balkan range (Samovodene C; Kachitsa) occupies an intermediate position between K IV and the Boian-Giuleşti group north of the Danube (Тодорова/Вайсов 1993, 127–142; Попов 1996, 89–92), which for its part merges with the Vădastra group. Based on a few ^{14}C dates, the chronological end of the Late Neolithic in the eastern Balkans might be marked by the end of the plateau in the calibration curve between 5190 and 5080 BC at some point in the 50th cent. BC (Görsdorf/Bojadžiev 1996; Krauß 2014, 209).

The rural economy of the Late Neolithic in the Balkans offered a good basis for the growth of population and at the same time required the development of new technologies for the more intensive use of the available resources. However, many of the technological developments can only be indirectly established from the archaeological finds. It pertains in particular to the firing technology which is expressed in a highly specialised ceramic production (Тодорова/Вайсов 1993, 97–147). Most likely also textile production was of considerable significance, considering the numerous find contexts with loom weights in settlements (Тодорова/Вайсов 1993, 184–186). Furthermore, many of the decoration patterns of Neolithic pottery are reminiscent of textile structures and the abundant clay stamps, known as *pintadera*, could have been used for the printing of textiles (Lichter 2011) (*fig. 4*). The production of polished stone tools and the working of bone and antler already reached the

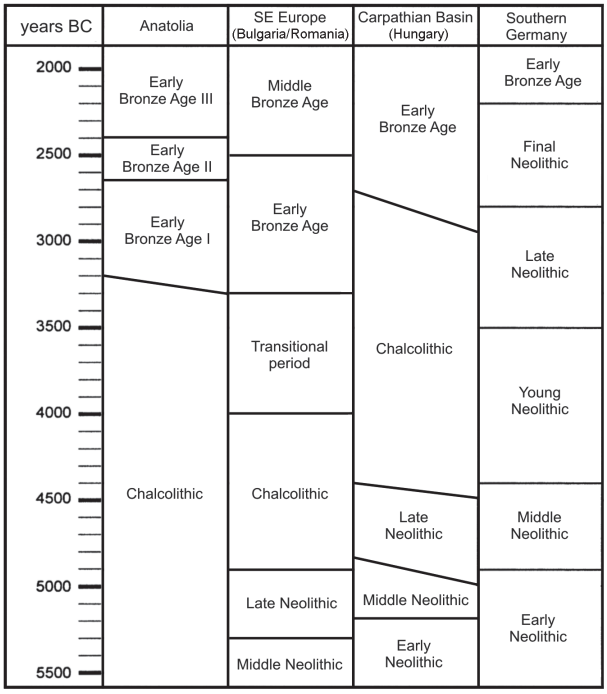

Fig. 5. Different terminology for the Neolithic-Chalcolithic Period in Europe (Bartelheim/Krauß 2012, fig. 6.1).

first climax in the Neolithic (Тодорова/Вайсов 1993, 179–183). In the Dobrudzha, burials outside of the settlements appear in considerable numbers for the first time with the Hamangia culture. Pieces of jewellery fashioned from the shells of the European *Spondylus* (*Spondylus gaederopus*) and *Dentalium* are also found with remarkable frequency within these graves (Todorova 2002).

Terminological Problems with the Research of the Chalcolithic

For the subsequent time interval from the 49th to 33rd cent. BC it appears justified to speak of a Chalcolithic because – in contrast to all other regions of Europe – the large number of copper and gold artefacts in the Balkan-Carpathian region is among the most striking elements of this period (Bartelheim/Krauß 2012). Beyond the raw material definition, structural changes within the social, economic, and religious realms are observable which permit the definition of a discrete cultural-historical epoch at the transition between the Neolithic and Bronze Age (see Lichardus 1991). A caesura, however, happens at 4200 BC in the form of changes in settlement pattern and metal technology for large regions of the eastern Balkans. After this point in time, a highly complex settlement system develops from the Danube delta to the northern edge of the Rhodope mountains, partially from existing Neolithic settlements. The defining character of this system is settlement mounds (tells) inhabited permanently over many generations. The ditches and palisades surrounding them were strictly respected, and the sites grew in height through building rubble, settlement waste, and ever new construction to an accumulation of settlement layers. Presently, however, it is generally accepted that these tells are only the most prominent part of a much broader settlement system. In many cases, there are indications of settlements around the tell itself, and various forms of non-Tell settlements are known far away from the mounds. There are also sign of pile dwellings at Lake Varna in this period. In the region of the lower Danube, almost all these tell settlements come to an end at the turn of the 43rd to the 42nd cent. BC. The following period is known as the transitional period (преходен период; epoca de tranziție) in Bulgaria and Romania and lasts until the re-establishment of Bronze Age tells in the Thracian plain in the 33rd cent. BC (*fig. 5*). This term was rejected by Lichardus with good reason (Lichardus/Lichardus-Itten 1993, 65–75), but in the countries of the eastern Balkans, it nevertheless continues to be used. In contrast to the earlier use of pure copper, hardened arsenical copper appears from the 36th cent. BC onwards with novel tools and weapons. Interestingly, the heavy tools disappear, and rather small-sized weapons and tools such as triangular daggers and flat axes as well as needles and jewellery dominate the metal inventory. Vajsov considered the appearance of arsenical copper as a precursor to bronze metallurgy, for which reason he suggested the term 'Proto-Bronze Age' for this cultural-historical episode (Vajsov 2002, 163 f.) (*fig. 6*). In the sense of Lichardus, this still concerns cultural groups of the Chalcolithic which existed parallel to Late and Terminal Neolithic in central Europe (see Lüning 1996; Schier 2010). The use of the term 'Proto-Bronze Age' based on the use of arsenical copper conceals the fact that in south-eastern Europe this type of metal was still in almost exclusive use during the

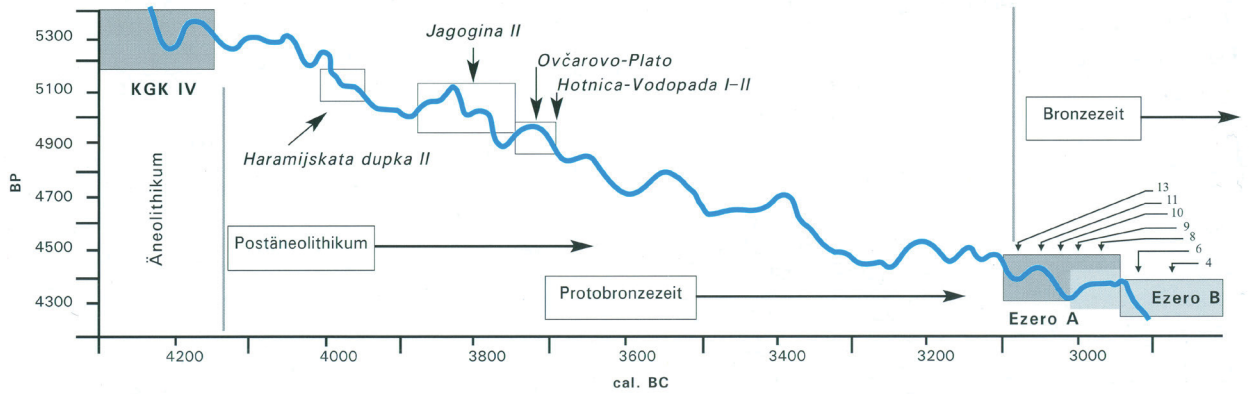

Fig. 6. Chronological table of the transition from Chalcolithic to Early Bronze Age in Bulgaria (Vajsov 2002).

entire Early Bronze Age instead of real bronze (as an alloy of copper and tin) (Черных 1978, 167 f.). Were the raw material definition to be taken alone, one would have to speak of a pure copper horizon until the 37th cent., and from thereafter until about 2000 BC, of an arsenical copper horizon. The use of metal hence does not run parallel to the demarcation of periods defined by research history. Only for reasons of comparability, we adhere to the traditional terminology in this volume. In what follows, the Chalcolithic (in its more restricted sense) hence denotes only the 49th to 43rd cent. BC and the transitional period (into the Early Bronze Age) the 42nd to 33rd cent. BC. For the latter period, in order to allow for various terms used in the contributions to this volume, the problematic subdivision of Vajsov into a 'Post-Chalcolithic' ('Post-Eneolithic') from the 42nd to 37th cent. BC and a 'Proto-Bronze Age' from the 36th to 33rd cent. BC has been maintained.

The settlements and burial sites of the Chalcolithic (i.e. of the 49th to 43rd cent. BC) in the Balkan-Carpathian area have produced a large amount of find material, and they are clearly visible from their elevated position as tell sites in the landscape. This was also the reason for them to be investigated early. In other parts of Europe, there are hardly any sites from this period that have produced similar amounts find material as the Chalcolithic tells of south-eastern Europe. Although the density of the sites and the amount of finds is so enormously high in this time horizon in south-eastern Europe, the methodological advances in northern, western, and central Europe left the impression that the societies of the European Neolithic developed socially and technologically at the same pace. Until the 1970s a greater cultural divide was identified only between the lands of the ancient Near East and perhaps also the cultures of the eastern Mediterranean, on the one hand, and Neolithic Europe on the other. Therefore, it can hardly surprise that the metal-rich graves of Varna were initially dated to the Bronze Age cultures of the Aegean. Apart from problems of chronology, the differences and diversity in terminology hampered a comprehensive understanding of the Chalcolithic in the region of the Lower Danube and Thrace until today.

Research about the chalcolithic settlements in this region may be traced back to the Shkorpil brothers who recorded the burial and settlement mounds along the Lower Danube (Шкорпиль 1896; Шкорпиль/Шкорпиль 1898; Шкорпиль 1905). In southern Bulgaria, the Augustine monk Frazier already excavated on the Racheva Mogila at Yambol in the year 1898 (Frazier 1901), and Seure and Degrand probed two settlement mounds at Zlatitrap and Kostievo in Thrace (Seure/Degrand 1906) with soundings. The first excavations by Bulgarian archaeologists were carried out under the supervision of Popov on the settlement mounds of Salmanovo and Kodzhadermen, and moreover in the caves at Dryanovo Monastery (Попов 1908; 1909; 1918; 1938). On the Romanian banks of the Danube for the first time Chalcolithic finds were identified at the settlements at Lake Boian next to Vărăşti and from Vădastra as well as on the tells of Cernavodă and Gumelniţa (Christescu 1925; 1927–1932; Schuchhardt 1924; Dumitrescu 1924; 1925). In his monograph on the prehistoric

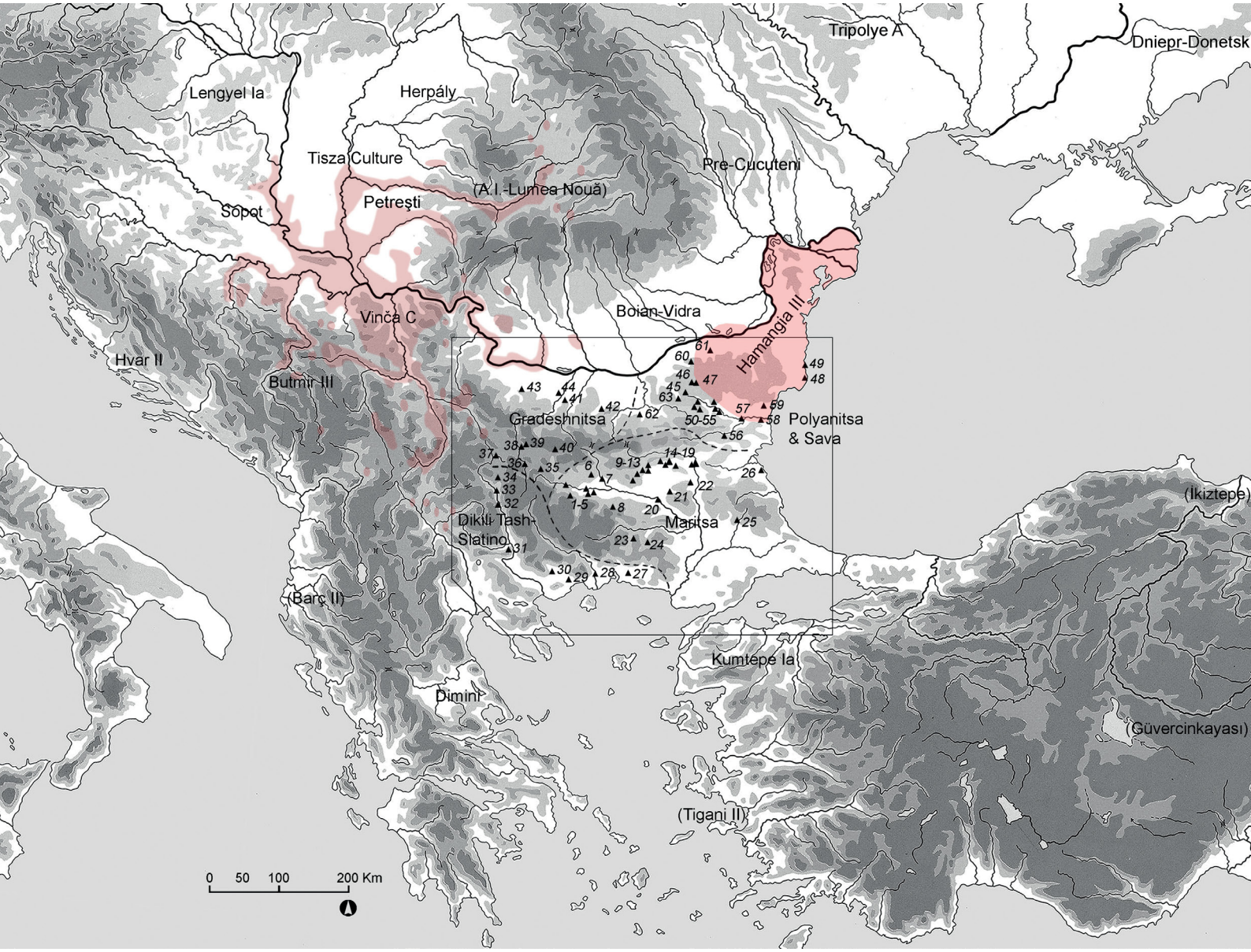

Fig. 7. Map of Early Chalcolithic settlements in the Eastern Balkans (49th – 47th cent. BC). Karanovo V (Maritsa) Group: 1 Yunatsite, 2 Kapitan Dimitrievo, 3 Kostievo, 4 Mechkyur, 5 Yasatepe, 6 Kukova mogila, 7 Borets, 8 Lenovo, 9 Chatalka, 10 Kirilovo, 11 Azmak, 12 Stara Zagora, 13 Kolena, 14 Karanovo, 15 Ezero, 16 Sadievo, 17 Bikovo, 18 Marcheva mogila, 19 Racheva mogila, 20 Devebargan, 21 Madrets, 22 Drama, 23 Sedlare, 24 Kromovgrad, 25 Aşağı Pınar, 26 Akladi Cheiri. Dikili Tash-Slatino-Group: 27 Paradimi, 28 Paradaisos, 29 Dikili Tash, 30 Sitagroi, 31 Topolnitsa, 32 Strumsko, 33 Slatino, 34 Dyakovo. Gradeshnitsa-Group: 35 Ihtiman, 36 Gorni Pasarel, 37 Pernik, 38 Chelopechene, 39 Buhovo, 40 Chelopech, 41 Telish, 42 Devetaki, 43 Gradeshnitsa, 44 Brenitsa. Polyanitsa- and Sava-Groups: 45 Drinovo, 46 Hissarlaka, 47 Radingrad, 48 Shabla, 49 Durankulak, 50 Polyanitsa, 51 Targovishte, 52 Ovcharovo, 53 Kodzhadermen, 54 Vinitsa, 55 Salmanovo, 56 Zavet, 57 Sava, 58 Golyamo Delchevo, 59 Varna Lake, 60 Kubrat, 61 Sokol (after Тодорова 1986; Nikolov 2002 and Чохаджиев 2007 with additions).

settlements and finds in Bulgaria, Mikov could already cite 132 Neolithic/Chalcolithic tell sites in northern Bulgaria and 89 more in southern Bulgaria (Миков 1933, 50–86). Gaul attributed them in his dissertation about the Neolithic in Bulgaria to what he termed a ‘mound culture’ and brought attention to the numerous copper finds from these settlements and their cultural significance (Gaul 1948, 79–207). By the excavations of Berciu on the settlement mounds of Tangîru and Petru Rareş a continual development of the Chalcolithic (Gumelniţa Culture) out of the local Late Neolithic (Boian Culture) could be established (Berciu 1961, 367–505). Thanks to Berciu a stratigraphic order

of the finds of the previously excavated tell of Sălcuţa in Oltenia became available (Berciu 1961, 193–337). It was also this work which could explain the main features of the relationship of the Oltenian finds to the development in Muntenia (Boian and Gumelniţa), north-western Bulgaria (Krivodol), and Serbia (Vinča and Bubanj) (Berciu 1961, 80–115). Finally, of considerable significance for the structure of the Neolithic/Chalcolithic development in Thrace and north-western Bulgaria were the aforementioned excavations at the tell of Karanovo near Nova Zagora (Georgiev 1961), and those of Gradeshnitsa, and Krivodol (Николов 1974; 1984) respectively.

This development of research, combined with nationalistic tendencies in the Balkan countries after the border adjustments in the course of the Balkan Wars and two World Wars is essentially the reason for the terminological diversity in the naming of the cultural groups of the Neolithic and Chalcolithic. Accordingly, the Early Chalcolithic in Serbia is characterised by the phases Vinča C and D, in northwestern Bulgaria by the late Gradeshnitsa, in northeastern Bulgaria and Muntenia by Boian, and in Thrace by the so-called Maritsa Culture (Karanovo V). Through excavation on various tell settlements in northwestern Bulgaria, Todorova additionally defined the so-called Polyanitsa Culture as a regional variant of the Boian culture in the regions south of the Danube (Todorova 1986). Indeed, various local expressions of ceramic production in different territories can hardly be denied. The nature of these settlements, with tells as the main feature and a general absence of burial places, alongside the remaining material culture, demonstrate far more similarities than differences within the greater Lower Danube region and the Balkan range. At least for Thrace, northeastern Bulgaria, and Muntenia, an exchange and communication system can be observed that also suggests a tightly knit social hierarchy. This broadly encompasses the Karanovo V, Polyanitsa, Sava, and Boian groups (Bolintineanu, Giuleşti and Vidra) defined by the ceramic material. Nevertheless, the transition of this cultural complex into the Hamangia Culture in the north-east, and the Dikili Tash-Slatino and Gradeshnitsa groups to the west is blurred (*fig. 7*). Tells form the central points of the settlements, with frequently attested fortifications consisting of surrounding ditches and palisades (Todorova 1981). So far, domestic structures are only known from these prominent settlement areas, although traces of settlements outside the tells can also be found, as in the case of mound Borovo in the district of Ruse (Krauß 2006, Kat.Nr. 140 and 143). Burials in cemeteries outside the settlements are still rare. A few known burial sites are found exclusively in the transitional zone with the Hamangia culture and are remarkably reminiscent of the local burial ritual (Lichter 2001, 45–74), consisting of extended supine burials and rare crouched burials resting on the left or, very exceptionally, right sides. With recourse to later developments, it can be supposed that the lateral crouched pose reflects local ritual, while the extended supine inhumations might be considered to be an adoption from the northern Pontic steppes transmitted by the Hamangia Culture (Lichardus/Lichardus-Itten 1998). The earlier, Neolithic graves from settlement contexts are, as a rule, laterally crouched. With the exception of the coastal zone of the Black Sea (Varna group), laterally-crouched inhumations remain the conventional burial convention for the entire Chalcolithic.

In the course of the Chalcolithic period, societies with complex structures and the aforementioned differentiated settlement systems and extreme disparities in the furnishing of graves developed in the central and eastern Balkans. In accordance with the terminology based upon prior literature, the groups from the central Balkans are combined into the Krivodol-Sălcuţa-Bubanj Hum I complex (KSB I for short), and those of the eastern Balkans into the Kodžadermen-Gumelniţa-Karanovo VI complex (KGK VI for short). The KGK VI complex extends across the Black Sea coast roughly from the mouth of the Danube in the north to the Strandzha Mountains in the south. Inland, it encompasses the Danube Basin up to around the river Yantra, and, south of the Balkan range, the entire Thracian plain (*fig. 8*). Here, however, the borders with the KSB I complex in the west are also blurred; in particular, the region between the rivers Yantra and Vit, both tributaries of the Danube, is poorly researched, and the broad gap of finds across the Danube basin might only be explained in this manner. Only the Rhodope mountains and the Rila massif in the

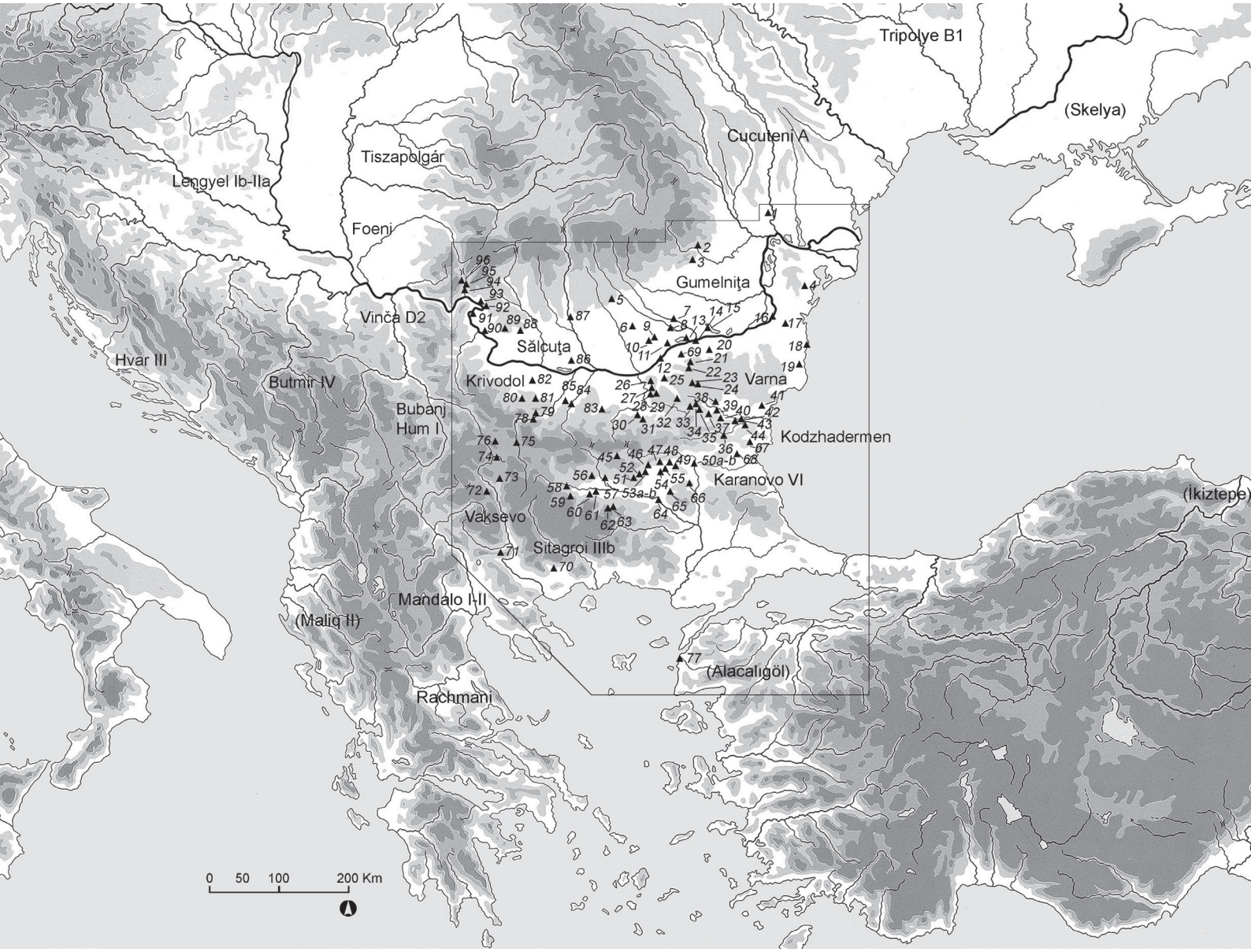

Fig. 8. Map of Late Chalcolithic settlements in the eastern Balkans (46th – 43rd cent. BC). Gumelniţa-Area: 1 Stoicani, 2 Aldeni, 3 Monteoru, 4 Baia, 5 Teiu, 6 Blejeşti, 7 Glina, 8 Vidra, 9 Tăngiru, 10 Petru Răreş, 11 Pietrele, 12 Ruse, 13 Căscioarele, 14 Gumelniţa, 15 Sultana, 16 Cernavodă, 18 Costineşti. Kodzhadermen-Area: 20 Sokol, 21 Kubrat, 22 Kamenovo, 23 Razgrad-Hissarlaka, 24 Radingrad, 25 Cherven, 26 Volovo, 27 Borovo, 28 Pet Kladentsi, 29 Koprivets, 30 Hotnitsa, 31 Veliko Tarnovo-Trapezitsa, 32 Nevski, 33 Polyanitsa, 34 Targovishte, 35 Ovcharovo, 36 Zavet, 37 Vinitsa, 38 Kodzhadermen, 39 Salmanovo, 40 Smyadovo, 41 Varna Pile Dwellings, 42 Komunari, 43 Sava, 44 Golyamo Delchevo, 69 Kosharna. Varna-Area: 17 Medgidia, 19 Durankulak, 41 Varna Lake. Karanovo VI-Area: 45 Gabarevo, 46 Kolena, 47 Karanovo, 48 Sadievo, 49 Bikovo, 50a Marcheva mogila, 50b Racheva mogila, 51 Chatalka, 52 Azmak, 53a Stara Zagora county hospital, 53b Stara Zagora mineral baths, 54 Zagortsi, 55 Ezero, 56 Kukova mogila, 57 Borets, 58 Yunatsite, 59 Kapitan Dimitrievo, 60 Mechkyur, 61 Plovdiv-Yasatepe, 62 Dolnoslav, 63 Lenovo, 64 Devebargan (Maritsa), 65 Madrets, 66 Drama-Merdzhumekya, 67 Kozareva mogila, 68 Burgas. Vaksevo and Sitagroi-Areas: 70 Sitagroi, 71 Musochina, 72 Vaksevo-Skaleto, 73 Dyakovo, 74 Pernik Krakra, 75 Okolglava, 76 Peklyuk. NW-Anatolian Late Chalcolithic: 77 Alacalıgöl. Krivodol-Area: 78 Rebarkovo, 79 Zaminets, 80 Krivodol, 81 Ohoden, 82 Hayredin, 83 Devetaki, 84 Sadovets-Golemanovo kale, 85 Telish-Redutite. Sălcuţă-Area: 86 Vădastra, 87 Slatina, 88 Sălcuţa, 89 Verbicioara, 90 Gîrla Mare, 91 Ostrovul Simian, 92 Turnu Severin, 93 Peştera Gaura Ungurului, 94 Băile Herculane-Peştera de sub Piatra Băniţii, 95 Băile Herculane-Peştera Hoţilor, 96 Mehadia (after Krauß 2008 with additions).

south-west form a natural boundary permitting a tangible differentiation from the next sites in the Struma river valley and on the plateau of Sofia. Research into settlement structure of this period reveals a diverse pattern with ranked and differentiated settlements beyond the well-studied tell settlements (see Todorova 1982) which might be encountered in the various expressions of satellite settlements of tells (Hansen/Toderaș 2010), smaller settlement sites remote from tells (Krauß 2010), and production sites (Manolakakis 2005, 29–36; Nikolov 2012, 21–26). Moreover, within tell settlements, new research has been able to distinguish between different residential and production areas (Reingruber 2010).

Sociocultural Dynamics during the Chalcolithic

The early phase from the 49th to the 43rd cent. BC which, as described above, denotes the Chalcolithic in its narrow sense according to the terminology conventionally used in Bulgaria and Romania is comparatively well-researched. As in the preceding Neolithic, agriculture and animal husbandry formed its economic foundations, although in most cases, the traces of Chalcolithic agriculture seem to have disappeared due to later farming. Nevertheless, based on pollen profiles and the analysis of food remains, many varieties of wheat and barley alongside pulses, fruits, and vegetables were identified (Marinova 2006). These were probably grown in gardens and on arable land, presumably in the vicinity of settlements. To these crops, wild plants from woodlands, grazing pastures, and the banks of rivers and lakes were added. Hence, the basis of subsistence was, as in the Neolithic, developed land cultivation and animal husbandry, although hunting and fishing also played an important role again. Interestingly, hunting was of even greater importance than before in the Neolithic, suggesting a diversified and extensive use of available resources. In any case, social inequality seems to be very clearly reflected in the settlements and graves of Chalcolithic communities. Besides settlements with stone architecture (Durankulak, Suvorovo, Avren), which possibly functioned as central locations, sites exist with clear specialisations in the exploitation of particular resources such as salt (Provadiya), copper (Akladi Cheiri) or flint (Kamenovo; Lavino).

Beginning with the 48th cent. BC, various cemeteries are known to exhibit a clearly differentiated burial ritual. Alongside the excessively richly furnished graves of Varna are also some burials from Provadiya, which were located in refuse pits for broken briquetage vessels or in their immediate vicinity (Nikolov 2012, 46–48). In many cases, only individual skeletal elements were discovered, but two complete individuals could be recovered which were evidently intentionally buried at this unusual place. The only grave good which could be documented was a stone axe. Whether the deceased were members of the lowest social class of Chalcolithic society which had to harvest salt or victims of blunt force injuries which were simply buried on the spot is unknown. Studies of the skeleton from the richest grave by far of Varna, Grave 43, by Zäuner revealed that even exceptional individuals within the Chalcolithic society were compelled to work (Krauß et al. 2014b). Possibly, physical fitness was even a prerequisite for their high status. Specialised combat weapons, such as axes from stag antler and stone hatchets, and later copper axes and hatchets could have been used to implement claims to power and maintain unequal power relations. Many of those buried, for example, at the tell of Yunatsite, exhibit signs of the use of violence on their skeletal remains (Balabina/Mishina 2011; Zäuner 2011).

A special treatment of deceased is suggested by the discovery of so-called ‘skull roundels’ (Georgieva/Russeva 2016). Some of the inhumations of this period display defects in the cranial vault which indicate a *postmortem* or even *perimortem* removal of portions of the cranial plate. Whether these observations point to a trophy ritual, in which the victory over a rival in battle is staged, as has been discussed for the skull roundels of the central European Iron Age (Röhrer-Ertl 1994), remains impossible to decide based on the present evidence. Five skull roundels from the Kozareva Mogila and

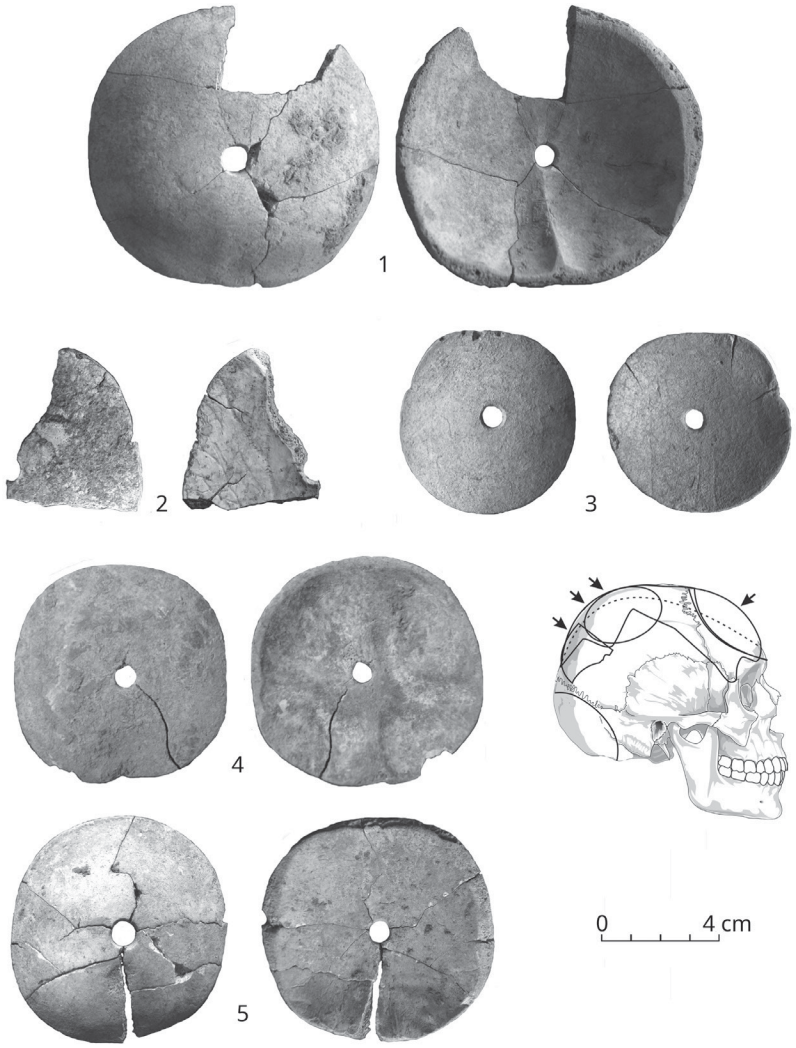

Fig. 9. Skull roundels and a skull calotte from Kozareva mogila (after Georgieva/Russeva 2016).

a past find from the site of Rakla can certainly be dated to the Chalcolithic (Georgieva/Russeva 2016) (*fig. 9*). To these, two unpublished examples from Akladi Cheiri, the anthropological or potentially zoological appraisal of which is still pending, might be added. In this context, some work tools fashioned from human bone found at Pietrele are also significant (Hansen et al. 2008, 92 f.); these have already been referred to by Georgieva and Russeva. The appropriative handling of human skeletal remains is not an exclusive speciality of the south-eastern European Chalcolithic. This is indicated by roughly contemporary finds from central Europe. Two skull roundels from the vicinity of Sommerein in Lower Austria (Winkler 1986) were found with sherds of *Notenkopf* pottery (Melzer 1986). Human skeletal elements reworked postmortem are known in large numbers from 5th mill. BC sites in central Europe, such as Herxheim, Achenheim, and Bergheim (Zeeb-Lanz 2016; AiD 2016). Furthermore, a fragment of a cleanly cut skullcap deriving from the Kozareva Mogila (Georgieva/Russeva 2016) is reminiscent of the many skullcaps of the settlement ditches of Herxheim (Zeeb-Lanz 2017).

A human skull fragment from the settlement of Bolgrad has even been linked to cannibalistic practices within the burial ritual (Dambricourt Malassé et al. 2010). The occurrence of artefacts made of human bones in the Chalcolithic settlements in the eastern Balkans is, therefore, hardly an isolated case. Rather, the preparation of amulets or tools from human bones can be seen as expressing a powerful sway over human beings, even beyond their physical death.

The development of metal weapons led to the fortification of settlements, especially the tell settlements, as an outstanding feature of the settlement system (Ivanova 2008, 123–147). These

weapons and fortified settlements could not only have served in internal conflicts but also against an exterior threat to the Chalcolithic communities. However, this is contradicted by the widespread distribution of both copper weapons and fortified settlements throughout the eastern Balkans from roughly the 46th cent. BC onwards. It is also conceivable that the unequal distribution of resources that is visible in the settlements and graves may have resulted in social tension and conflict between regions with different access to raw materials. High population pressure, as might be supposed from the dense distribution of Chalcolithic tell settlements, and competition for limited resources could have given reason for the rise of aggression, but also for an enhanced desire for protection. The development of metallurgy forms only one element in a larger framework of intensive raw material use, technological progress and the development of weapons. Accordingly, these innovations could have been triggered by the social development in the preceding Late Neolithic. Technological innovations seem to proliferate particularly quickly in communities with higher population densities and more developed social structures. Since a high density of settlements is already recognisable in the Late Neolithic, which could have resulted in a certain degree of social stratification, it is reasonable that this development almost inevitably peaked in the emergence of the complex society of the Chalcolithic. Certainly, the social differentiation that is evident in the graves and settlements of the Chalcolithic is inconceivable without the historical forerun in the Late Neolithic, where the roots of many technical developments may be traced. Inasmuch, the emergence of Chalcolithic society may be understood as the direct consequence of social development during the Late Neolithic. With the advent of the Chalcolithic, an even more pressing demand for resources may be assumed which, in the use of the same natural environment with its limited potential, required differing patterns of behaviour. On the one hand, a heightened preparedness for technological innovation is to be expected, which made possible a more effective use of resources. However, on the other hand, spatial proximity to neighbours forced communities to either cooperate in the use of these resources or to develop means of coercion so as to achieve sole control over them. Both a heightened propensity to innovation and various cooperation strategies but also methods of exercising power can be observed in the Chalcolithic of the Balkans, and they may have contributed to the emergence of developed copper metallurgy.

On the Chronology of the Chalcolithic Tell Settlements and the Cemetery of Varna I

Numerous well-documented stratigraphies of tell sites in the eastern Balkans were compiled to a reliable relative chronology of Chalcolithic find material since almost half a century (Berciu 1961; Тодорова 1986; Parzinger 1993). In the acquisition of absolute dates through radiocarbon dating, the Berlin laboratory of the Academy of the Sciences of the GDR played a pioneering role. For a long time, samples of Bulgarian, Romanian, and Yugoslavian sites, were regularly analysed there between 1962 and 1995 and served as the foundation of the absolute chronology of the region (Quitta/Kohl 1976; Görsdorf/Kohl 1992; Görsdorf/Bojadžiev 1996). Remarkably, the relative chronology, according to their stratigraphic sequence was already included in the modelling of the data. Accordingly, the settlement sequences of the tell settlements of Ovcharovo, Yunatsite, (Görsdorf/Bojadžiev 1996, *fig. 8–9*), and Ezero (Weninger 1995) can be comparatively exactly established. However, there are three problems with the Berlin dates. Initially, the uncertainty of measurement of the radiocarbon dates was between ±200 to ±100 years. Even when the standard deviation was reduced to ±80 to ±40 years from about 2000 onwards, it remained large in comparison with modern AMS dates. A further problem was the comparatively large sample size required for conventional measurements. In order to obtain the required mass of carbon, often composite samples were measured. Also, with single samples, the total amount required was usually so large that it contained contaminations such as fine roots, remains of mould, fungus, and other microorganisms, which in many cases rendered the measured age much younger. A third problem was the sample material itself that consisted overwhelmingly of charcoal, the evaluation of which was hampered by the ‘old wood effect’,

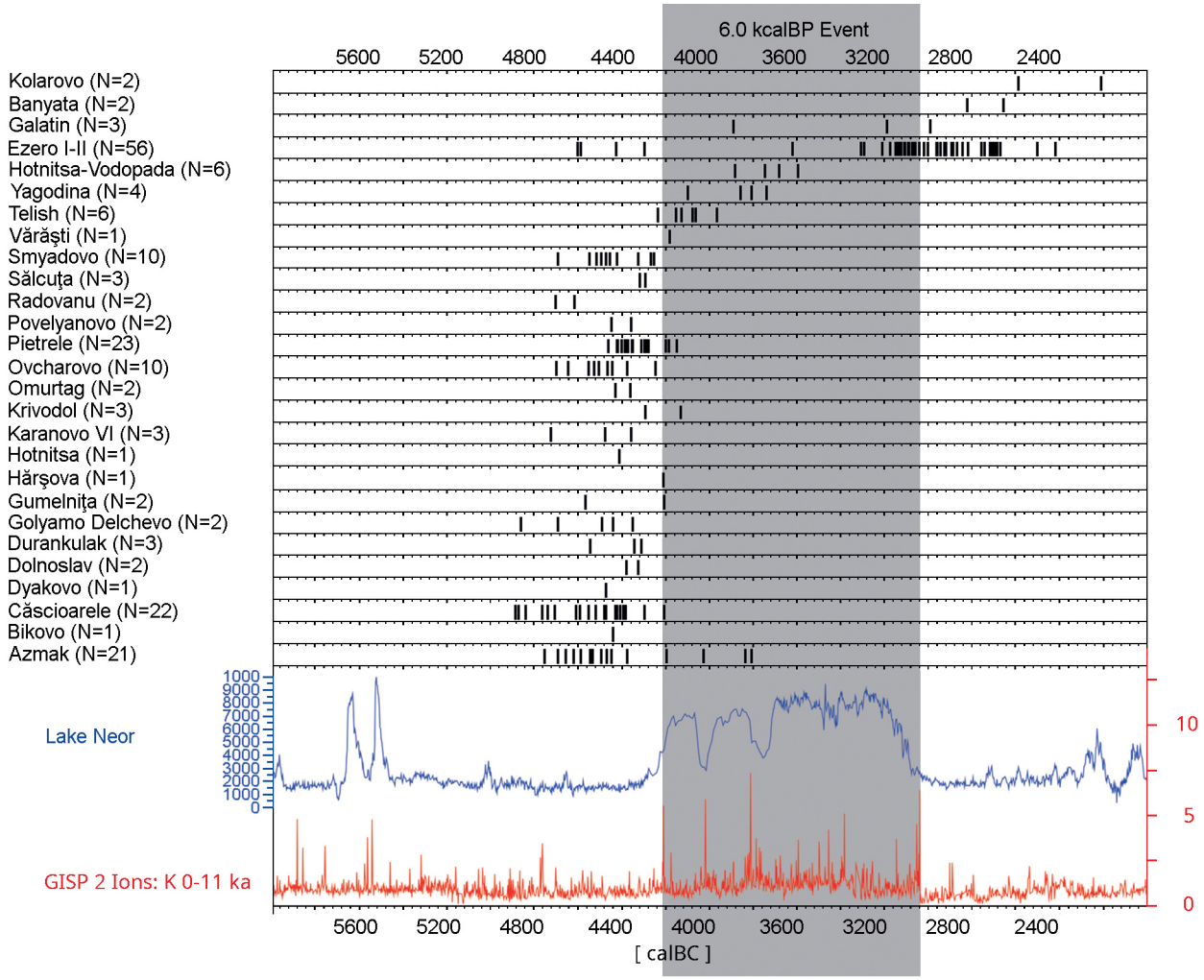

Fig. 10. Multigroup calibration of ^{14}C dates from Chalcolithic settlements in Bulgaria and Romania with the program CalPal (Weninger 1986). The end of the tells on the Lower Danube corresponds with the beginning of the RCC 6.2 kcalBC event (Weninger et al. 2009, 42–47). Climate records from GISP 2 Greenland ice core (Mayewski et al. 1997) and dust deposits at Lake Neor (Sharifi et al. 2015) (courtesy to Bernhard Weninger, Cologne).

that is the uncertainty from which part of a timber the charcoal sample derived. Moreover, the possibility of a very long period of use for the timber and repeated reuses preceding the timber's burning and arrival in its find context should be considered. Therefore, later series of radiocarbon dating of short-lived samples like logging waste or plant seeds from stratigraphically secure levels are of particular interest. Modern AMS laboratories work with much smaller sample sizes, which can be much better cleaned of possible contaminations.

During the last 15 years, further advances in the modelling of ^{14}C dates in accordance with their archaeological contexts were achieved. Most notably are the method of Bayesian calibration with the assistance of the program package OxCal (Bronk Ramsey 2009) and the method of the Gaussian Monte Carlo Wiggle Matching (GMCWM) based on the calibration software CalPal (Weninger/Jöris 2002). Rather than calibrating the ^{14}C dates individually, complete data sets with an archaeologically defined internal structure are used. This structure can be predefined by means of the position of the sample in a stratigraphical sequence, the definition of *termini post* or *ante quos*, or the order within a correspondence analysis. With the GMCWM procedure, in this manner, the data series of the tell of Pietrele could be calibrated according to the stratigraphic position of the samples (Weninger et al. 2010). In combination with the relative chronologically of settlement stratigraphies from tell settlements fixed series of ^{14}C dates provide a robust and absolute chronological framework for

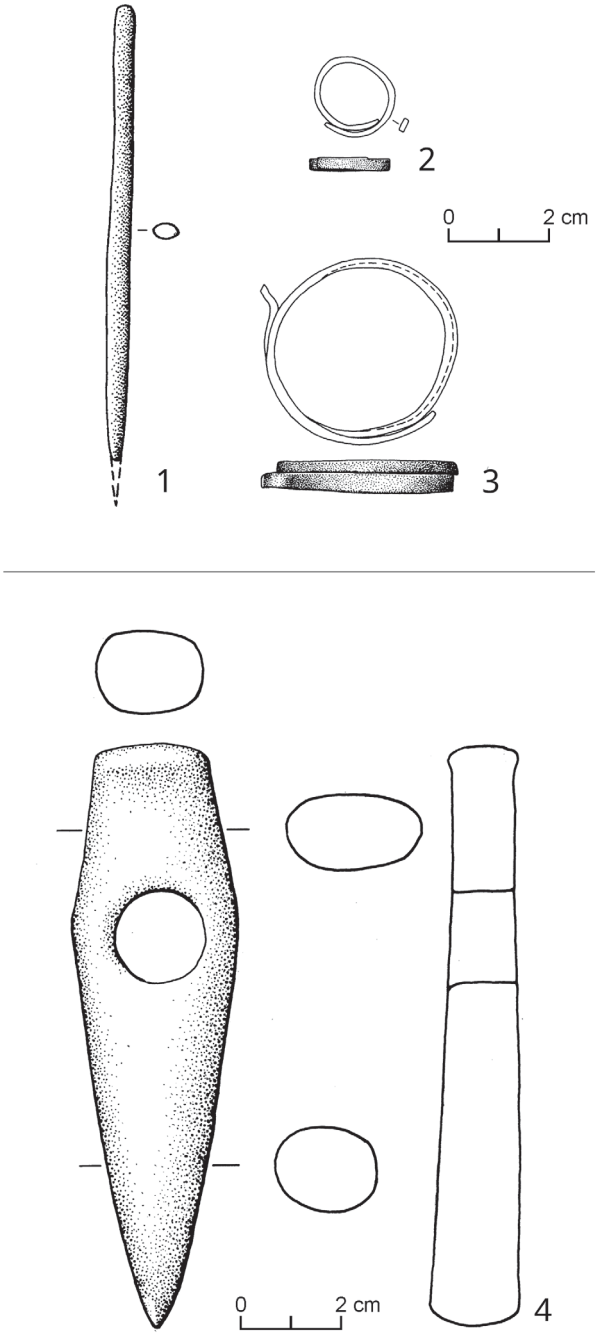

Fig. 11. Late Chalcolithic cemetery Varna I. Typical metal objects of the first phase: 1–3 two copper rings and a copper awl from grave 51 (♂, 20–40 years, supine), 4 copper hammer-axe type Pločnik from grave 116 (♂, 7–12 years, supine) (1–3 after Todorova/Vajsov 2001; Todorova 1981; 4 drawing Moni Möck. Anthropological determination Steve Zäuner).

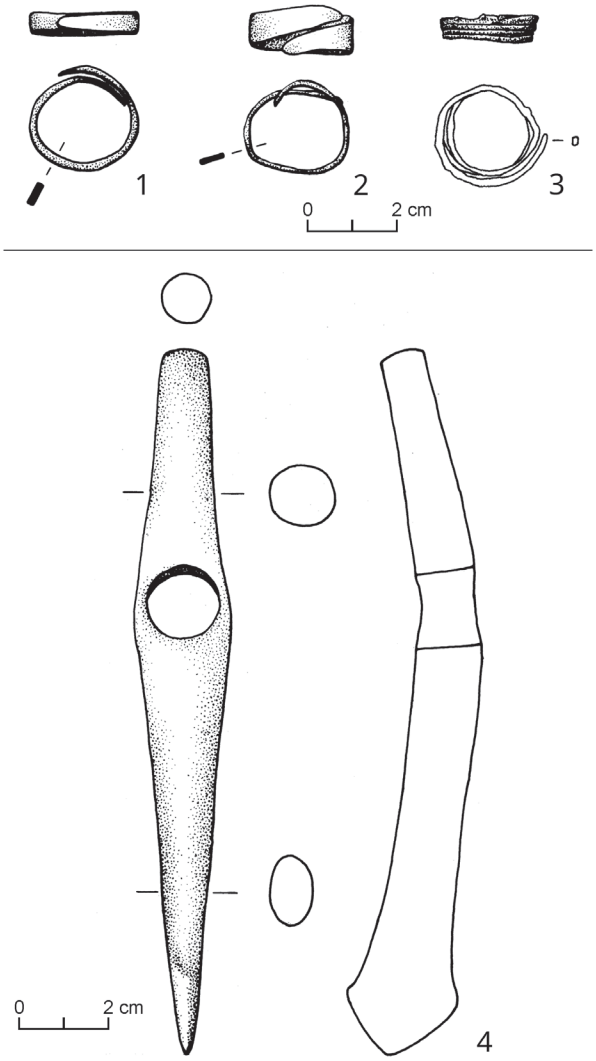

Fig. 12. Late Chalcolithic cemetery Varna I. Typical metal objects of the second phase: 1–3 three copper rings from grave 60 (20–40 years, crouched right), 4 copper hammer-axe type Devnya from grave 229a (anthropologically indeterminable) (1, 2, 4 drawing Moni Möck, 3 after Todorova/Vajsov 2001. Anthropological determination Steve Zäuner).

the development of the Chalcolithic on the Lower Danube and in Thrace (*fig. 10*).

The statistical evaluation of radiocarbon dates from the cemetery at Varna resulted in a chronological framework for the 47th to 44th cent. BC independent of the settlement's development.[1] The results are of great significance not only for the understanding of the development of the burial rites, but also for the development of the metal tools which were deposited in burials as grave goods. Although the cemetery was established on the banks of Lake Varna, the depth of graves is not

1 The results will be published in the catalogue of finds of the cemetery of Varna in a series of the Eurasia department of the DAI. Individual results of the statistical evaluation, above all the analyses relating to chronology have already been reported in individual papers (Krauß et al. 2014b; 2016).

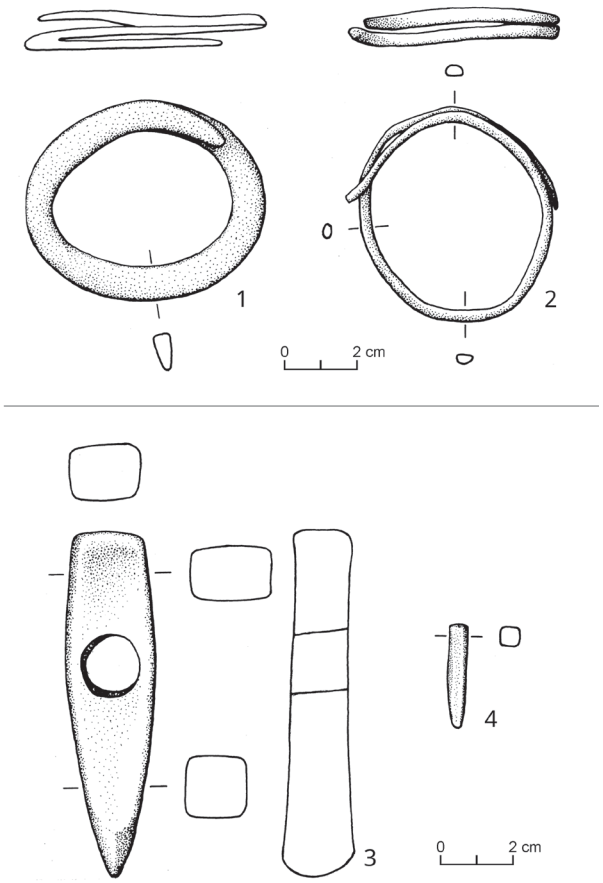

Fig. 13. Late Chalcolithic cemetery Varna I. Typical metal objects of the third phase: 1–2 two copper bangles from grave 126 (♂, 20+ years, supine), 3–4 copper hammer-axe type Pločnik and copper awl from grave 143 (♂, 30–40 years, supine) (Drawings Moni Möck. Anthropological determination Steve Zäuner).

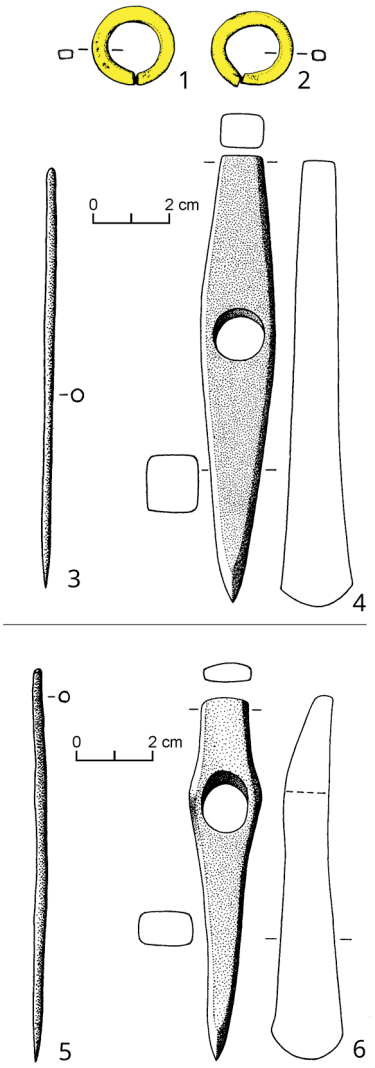

Fig. 14. Varna I. Typical metal objects of the fourth phase: 1–4 two gold rings, a copper awl and a hammer-axe type Čoka-Varna from grave 6 (♂ ?, 30–35 years, supine), 5–6 copper awl and hammer-axe type Vidra B from grave 92 (♂, 50+ years, supine) (1–2 drawing Moni Möck, 3–6 after Todorova 1981. Anthropological determination Yordan Yordanov [grave 6] and Steve Zäuner [grave 92]).

related to their height above sea level. Cultural reasons seem to have been far more decisive for the depth and size of the graves, as a relationship seems to exist between deep and large graves and particularly rich furnishings. The age of the deceased seems to have had only a marginal influence on the style of burial and relative wealth of the grave. The heavy copper implements exhibit a development from initially simple forms of hammer-axes (Pločnik and Varna types) still reminiscent of their stone precursors into hybrid and technologically very complex forms, such as the gracile types (Vidra and Devnya) (*fig. 11–16*). The successive replacement of copper jewellery by golden jewellery is distinct as well, as is the transition from *Spondylus* – initially predominant in the production of jewellery – to *Dentalium*. The latter may be related to a change in availability of these mollusc shells which do not occur in the Black Sea and must have been provided by widely-strung networks extending from the Aegean. For the golden jewellery, the chronological resolution of the graves demonstrates a diversification of production and increasing technological complexity. Nevertheless, Varna I may not even represent the beginning of copper or gold metallurgy, as gold artefacts were found in one of the three graves of the Varna II burial site that is chronologically somewhat earlier like several other small grave groups that may be considered as predecessors to Varna I.

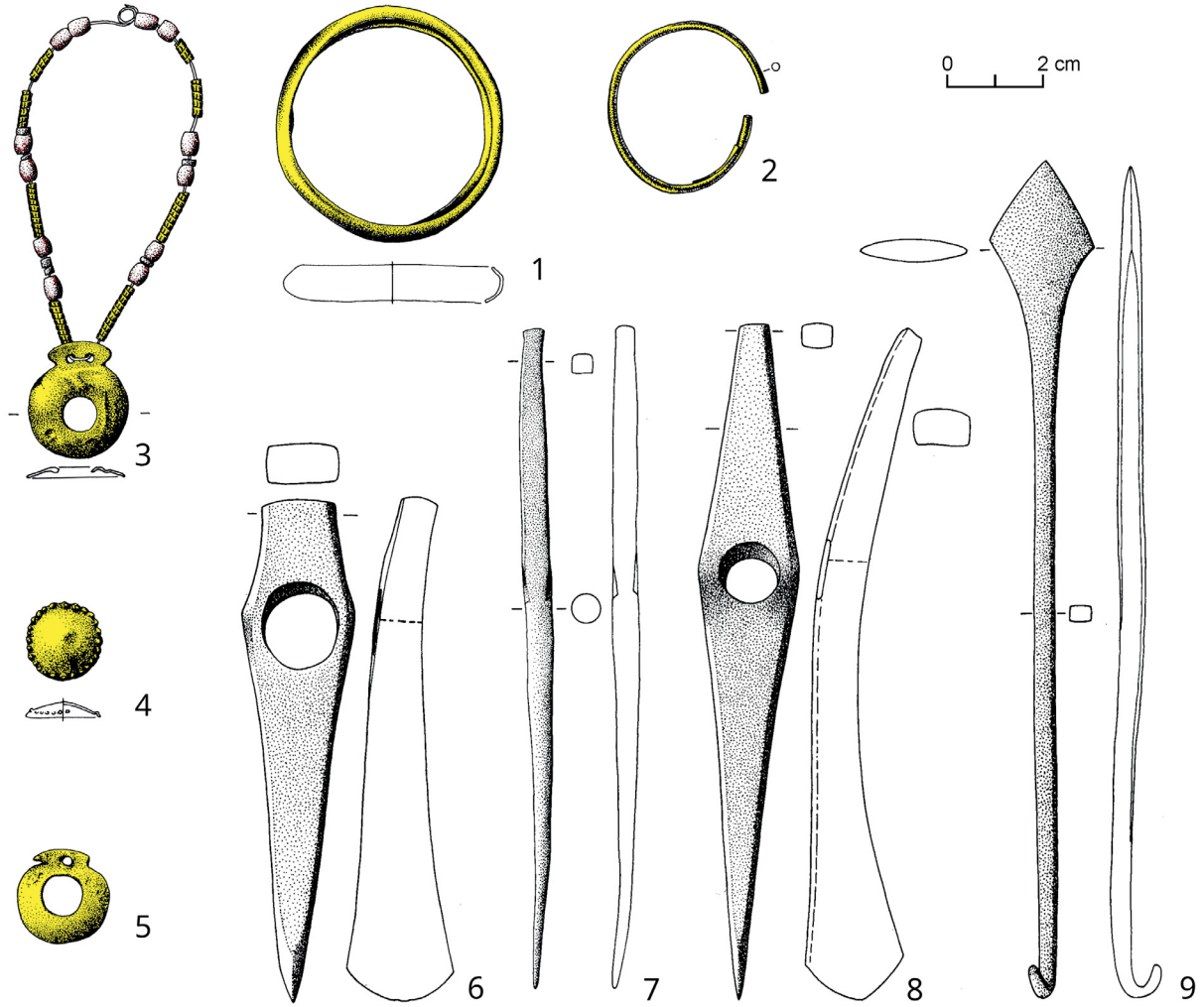

Fig. 15. Varna I. Typical metal objects of the fifth phase: two golden arm rings, a jewellery chain with a ring idol, a golden appliqué and another golden ring idol, a copper awl, spearhead and hammer-axes of type Vidra B and type Varna from symbolic grave 97 (1–5 after Todorova/Vajsov 2001, 6–9 after Todorova 1981).

In contrast, the advent of copper metallurgy is certainly to be sought some centuries before the beginning of the burial sites at Varna. In Varna I, however, the differentiation of metallurgical production from initially very simple types and technologically simple production techniques into hybrid objects, sophisticated methods of production, and serial finishing is very nicely documented. Although already in the graves of Varna II, and a few of the earliest graves of Varna I, the phenomenon of over-furnishing is encountered and there is also a decisive change in the materials of prestigious grave goods. At the beginning of the development, wealth is expressed in grave goods of *Spondylus* and copper jewellery, as well as antler and stone tools. In the end, it is gold and *Dentalium* jewellery as well as copper weapons, which characterise the distinguished graves. Within the development of the cemetery, not only do the grave goods expressing high prestige change but also other materials were successively used for the production of similar objects. It must, however, be kept in mind that the individuals buried at the cemetery of Varna I may encompass only a small part of a larger community that perhaps encompassed the entire hinterland of the Black Sea coast.

A mapping of the chronological phases of Varna I displays a development beginning in the north-west towards the south-east, that is in the direction of the bank of Lake Varna. Expressed in a different way, the development begins from the top and graves are built progressively further

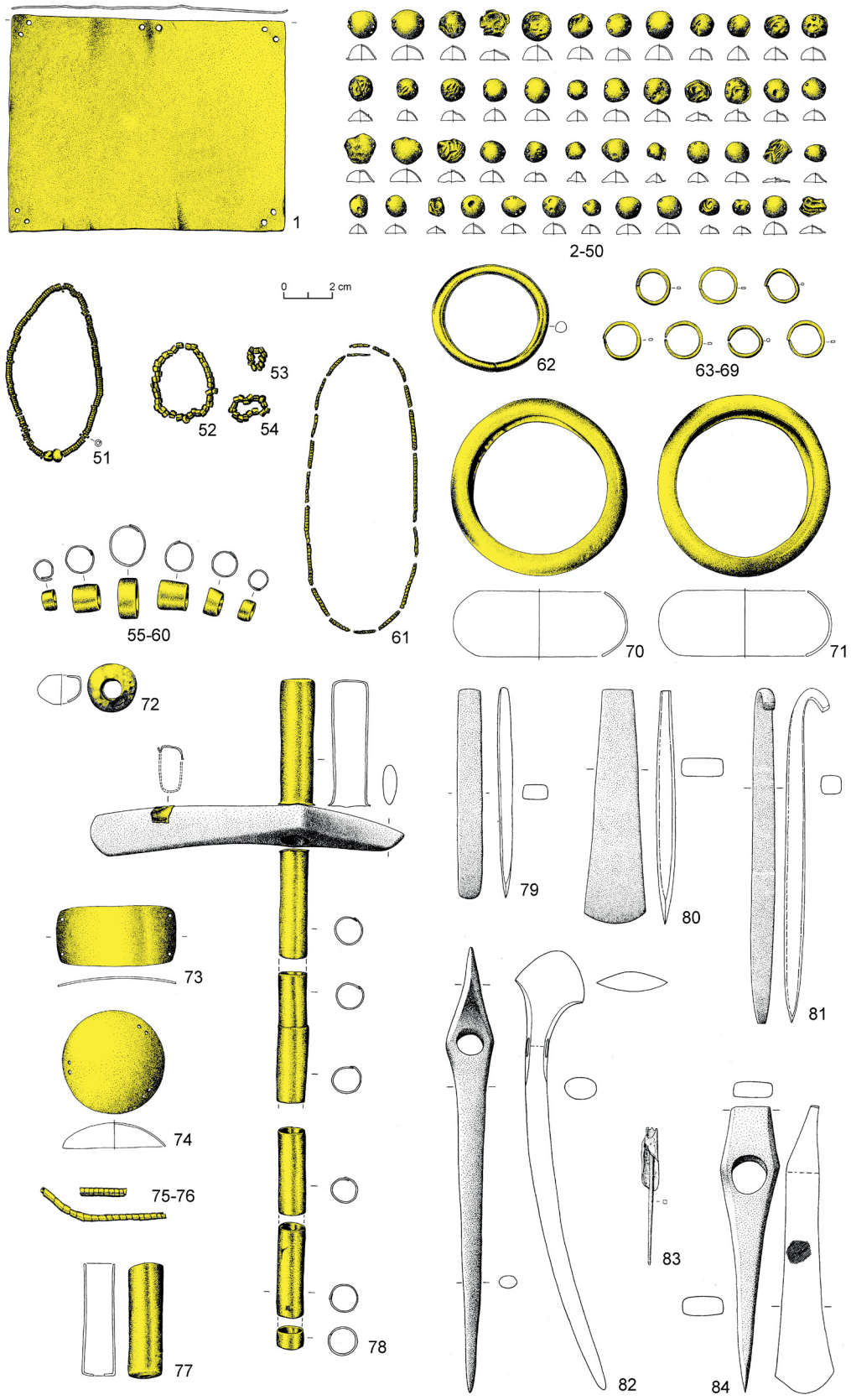

Fig. 16. Varna I. Typical metal objects of the sixth phase: golden applications, jewellery chains of gold beads, gold rings, golden arm rings, golden clasps of a bow, a stone axe sceptre with a gilded shaft, two copper adzes, a shafted copper spike, a copper pick and a hammer-axe type Vidra B from symbolic grave 4 (1–78 after Todorova/Vajsov 2001, 79–84 after Todorova 1981).

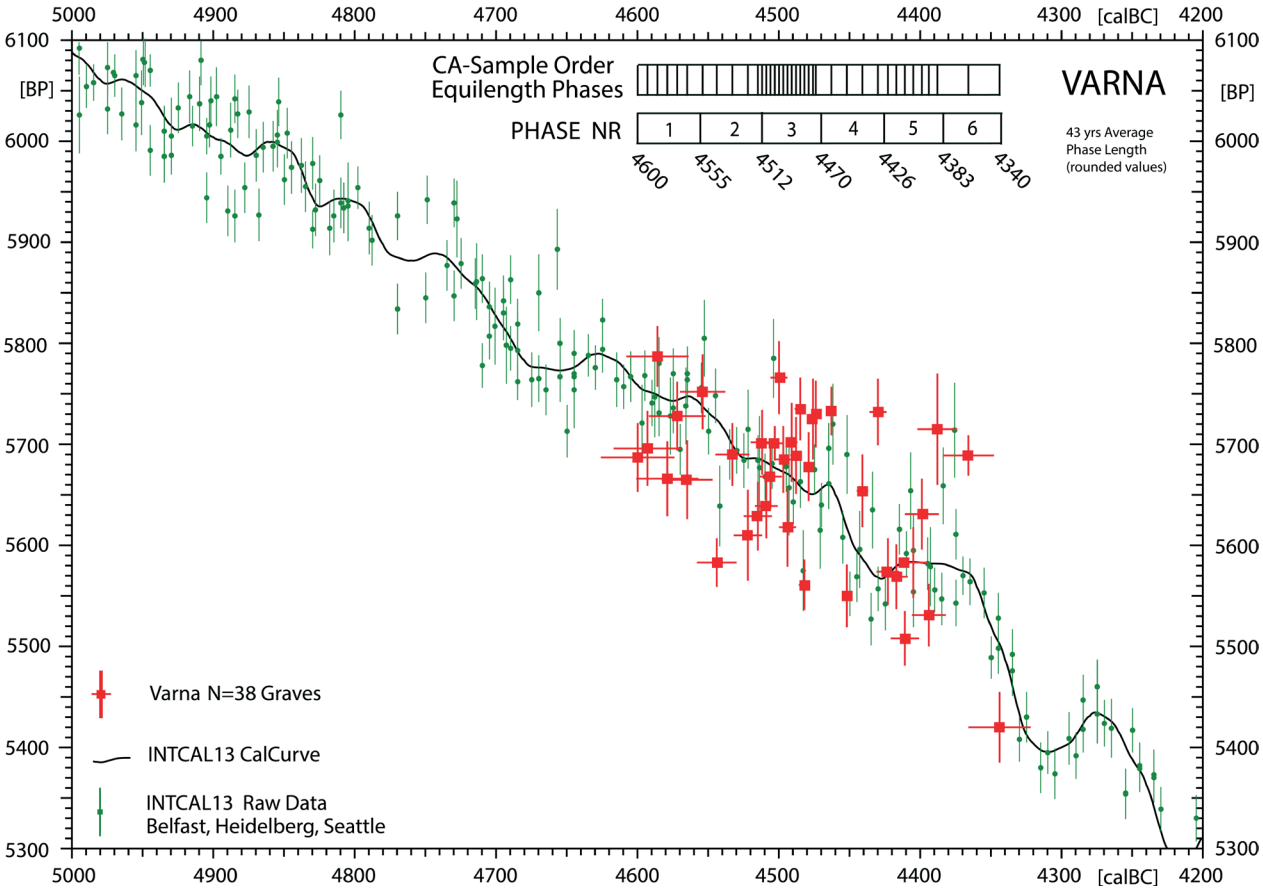

Fig. 17. CA-based ^{14}C chronology of the Varna I cemetery according to the relative chronological position of the graves within a correspondence analysis with primary quantified ^{14}C dates (after Krauß et al. 2017).

downhill. In the beginning, graves with skeletons in crouched and supine position predominate, while the laterally crouched examples are constantly decreasing over time. Most significant is the growing number of symbolic graves. Initially, these symbolic graves appear only to mark certain areas of the cemetery. In the final phases, however, very richly furnished symbolic graves occur, forming a straight line as a south-eastern border to the burial area. These deposits could be the material remains of various rituals which followed a boundary between the living and the dead at the end of the period of occupation. The chronological termination of the cemetery is formed by a group of symbolic graves as Cenotaphs 2, 3, and 15, in which roughly half life-sized sculptures with anthropomorphic heads of clay were deposited.

A combination of ^{14}C dates with statistically ascertained grave order confirms their chronological positions as the dates in their archaeologically determined order follow the calibration curve, but they also reflect individual wiggles of the curve (*fig. 17*). The modelling of the radiocarbon dates sets the beginning of Varna's cemetery at 4600 ± 30 calBC and its end at 4340 ± 30 calBC. The occupation period of 260 years obtained by the combination of statistical evaluation with the ^{14}C dates offers, with a total of not more than 270 physical burials,[2] some indications for the role of the cemetery in the context of the burial rituals of the KGK VI Complex. Even regarding the as yet unexcavated area of the burial site, the number of burials is evidently too small for a single site. Moreover, the small number of burials combined with the relatively large number of symbolic burials implies that a certain selection of individuals, possibly from different settlements, were buried here. It is possible that the significant surplus of

2 The varying statements of 269 or 270 physical graves in the literature are due to the different assessments of Grave 1. This complex unearthed in 1972 during development work led to the discovery of the cemetery but was also heavily damaged by this work. Many finds were only ascribed to this grave afterwards (Bojadžiev/Slavčev 2011, 15–17).



Fig. 18. Neolithic/Chalcolithic tell of Provadiya with pits containing the debris of pottery for evaporation to produce salt in the foreground and drawings of the briquetage vessels found therein. On top of the prehistoric mount an Iron Age tumulus was built, so the settlement accumulation only from the Neolithic and Chalcolithic is a bit smaller (Photos Lee Clare. Drawing Nikolov 2012, fig. 17).

male inhumations may also be explained by this model. The prominent significance of the northern bank of Lake Varna for Chalcolithic communities is already evident in the burial group of Varna II and further develops in Varna I into the richest symbolic graves on the south-eastern edge of the graveyard, which was turned into a sacred space by enclosing it. The search for a settlement related to the graveyard seems futile in view of its demographic data and chronological depth. Varna I might rather be understood as a distinguished burial ground within a large settlement area of the KGK VI complex, including the tell settlements in the hinterland of the western Black Sea coast.

Resource Management during the Chalcolithic

As already outlined, the subsistence for Chalcolithic society was provided by agriculture and animal husbandry but to a substantial degree also by hunting and fishing. In order to account for free capacities for various handicrafts identifiable for this time, a production of foodstuff beyond the individual requirements of the settlements has to be assumed. Among the crops emmer, einkorn, wheat and barley – that were introduced with the Neolithisation of south-eastern Europe – dominate (Marinova 2006, 79–86). From surviving foodstock a mixed cultivation of emmer and einkorn and a cultivation of genuine wheat and barley can be presumed. There are indications for successive sowing of grain and pulses, mainly lentils, ervils, peas and vetchlings. The grain was thus sown in autumn (due to winter hibernation) and the pulses also sown in spring/summer (Marinova 2006, 86 f.). The ears were harvested by chopping or breaking high up. Subsequently, the straw could be cut with sickles (Marinova 2006, 87 f.). The gathering of plants evidently was of lesser importance. Noteworthy, however, is a large stock of toxic nightshades from the tell of Pietrele (Hansen et al. 2008, 75 f.). These plants, toxic in all of their parts, possibly were collected because of their psychoactive properties. In the settlements, there is growing evidence for stockpiling, above all of the grain. These, together with the domesticates of sheep, goat, and cattle, also introduced in the Neolithic, create the base of nutrition. Sometimes indications of a specialised use of local food resources are found in the settlements. Among the butchery waste of the tells of Ovcharovo, Golyamo Delchevo, and Pietrele might, for example, large quantities of bones of wild animals are found which point to a specialised hunting of wild boar, roe deer, and red deer (Тодорова et al. 1983, 67–71; 1975, 75–80; Hansen et al. 2011, 58–60). The amount of red deer bones at the three sites exceeds even that of most of the domesticates identified. Only domestic cattle display a somewhat larger proportion among the butchery waste. The minimum number of killed red deer for Ovcharovo alone is 413 specimens (Тодорова et al. 1983, 68). In Pietrele, the proportion of waste from domesticates butchered for meat is at just 40% (Hansen et al. 2011, 58). Similar high values for the game are to be found at many other tell settlements. An appraisal of the herd patterns of domestic cattle, sheep, and goats also suggests a growing significance of dairy production during the Chalcolithic (Тодорова et al. 1983, 79). Finds of bone harpoons and clay weights interpreted as net sinkers and fishing hooks also demonstrate extensive fishing.

Large quantities of salt were required for the preservation of foodstuff, but also for various technological processes such as the tanning of hides. Recent excavations at Provadiya-Solnitsata studied such a production site (Николов 2008; Nikolov 2012). There, a settlement mound fortified by a drystone wall was established on a rock salt deposit already during the Late Neolithic. Springs fed from the surrounding highlands dissolve the salt underground and reappear as salt springs at several places in the vicinity of the tell. The technological process by which crystalline salt was produced during the middle of the 5th mill. BC at Provadiya might be reconstructed as follows: the brine was first collected in large pools and poured into special briquetage vessels (Nikolov 2012, 21–26). These are roughly tempered, funnel-shaped, wide-mouthed vessels and resting upon a small base. The surface of the vessels is roughened with wide finger grooves. Two small studs placed one below the other on both sides of the vessel served as load-bearers for its handling by means of two poles, or a single, large two-pronged fork. On some of these vessels, the exterior surface had received a coating of unfired clay. Seemingly, the



Fig. 19. Series of superblades made out of north Bulgarian radiolarite from Tell Sava. The longest piece has a length of 27.8cm (Slavchev 2007, 28).

vessels were specially finished with a grooved surface so that the clay would better cling to it. These briquetages occur in three standardised size classes of 1–1.2, 30–40, and 60–80 litres, respectively (Weller 2012, 73). Long rods of pottery with which the brine could be stirred also were found (Николов et al. 2009, fig. 24). The filled briquetages were subsequently deposited in fuel-filled pits and fired. Evaporated water could be replaced with brine by means of ceramic ladles again and again (Nikolov 2012, fig. 22) until finally a solid body of salt corresponding to the vessel size of between 2 and 110kg, was formed (Weller 2012, 80 f.). In order to remove the salt cone, the vessels were smashed and disposed of in large waste pits. From the fragmented briquetages, the tremendous scope of salt production can be assessed. Based on the volume of the Chalcolithic waste pits excavated up to the year 2010 a production of 45 to 90t salt in Provadiya alone was estimated (Weller 2012, 80), an almost 'industrial' scale of production (Nikolov 2012, 22).

Many of the objects found in the settlements and graves produced from inorganic and enduring organic materials permit the identification of a widespread network for the provisioning of raw materials during the Chalcolithic. While local deposits overwhelmingly provided the vast majority of stone tools in the eastern Balkans, there were also objects which demonstrably were made from imported raw materials. One of the most important local raw materials of the Chalcolithic was the very homogenous radiolarite from deposits in the neighbourhood of Razgrad in north-western Bulgaria. The examination of one of the quarrying sites of these flint types at Kamenovo in the district of Razgrad began in 2016 (Бояджиев et al. 2016). The masses of lithic flakes, half-finished products,



Fig. 20. Hoard of axes from Alpine jadeite from Svoboda (Pétrequin et al. 2012, fig. 14).

and broken finished tools in the archaeological record are clear signs of on-site production. From a more distant site, known for a long time, at Lavino, south of Isperih there are indications for the mining for flint.[3] The material extracted there is particularly suitable for the production of so-called superblades (*fig. 19*), extremely long flint blades up to a half metre in length, which can be produced by means of extremely elaborate pressure techniques (Manolakakis 2005, 265 f.). Experimental archaeology suggests the use of a complex lever apparatus in the serial production of these blades (Pelegrin 2007). For the tip of the lever, different materials were tested, of which interestingly a small copper thorn proved to be particularly efficient. It may be regarded as a multiplier effect, as it was only with the availability of copper that this type of blades could be produced. Likewise, red quartz (carnelian), from which small jewellery beads were manufactured was locally available in the Balkans. However, some of the artefacts found in the cemetery of Varna consist of stones which do not occur in the Balkans. Accordingly, they must have been imported, such as the obsidian for a blade from the symbolic Grave 41 of the cemetery at Varna. The small obsidian outcrops in Bulgaria in the Rhodope mountains and on the Black Sea coast (Kunov et al. 2003) do not seem to have been exploited in prehistory. The geographically nearest deposits, exploited already since the Neolithic are those of the Cycladic island of Melos and those of the northern bend of the Carpathians.

For the reconstruction of long-distance contact, the discoveries of stone hatchets of Alpine jade, for which an origin from deposits in Piedmont, northern Italy, is considered (Pétrequin et al. 2012) are particularly instructive. The jadeite hatchets from

3 Personal communication Kalin Dimitrov.

Grave 1 and Grave 3 from the small burial group of Varna II, as well as from Grave 1035 from the cemetery at Durankulak, are the earliest examples found in Bulgaria. A radiocarbon date obtained from an antler pick from Grave 1 at Varna II points to the 48th cent. BC. Even if this may be an object with an extended life of use, it cannot be dated later than the 47th cent. BC based on other finds in this grave. The obvious question, whether only the stone material reached the Balkans and then was worked into a hatchet, or whether finished jade hatchets arrived by means of exchange networks can be answered with relative ease in this case, because two of the four jadeite hatchets from Varna II have a clearly atypical form for the find region. The shape rather resembles types known from western Europe (Pétrequin et al. 2012, 1278). From a practical point of view, it seems unlikely that an unshaped stone material was transported over a distance of 1700km. The characteristic green colouring of the material only appears on the polished stone and leaves the hatchet gleaming in the colour of oxidised copper. Not only individual examples of western European jadeite hatchets reached the Balkans, but also larger batches arrived by the 48th cent. BC. This is strikingly demonstrated by the discovery of a hoard of at least 28 hatchets from Svoboda in Thrace (*fig. 20*). This is indeed the most extensive deposit of jadeite hatchets in Europe (Pétrequin et al. 2012, 1246–1252). Many of the pieces from the hoard of Svoboda may also be categorised as Western European types. Others, in contrast, match smaller, local types and seem to have been reworked from those. The phenomenon of reworking also characterises the following find horizon of the Varna period. In Grave 43, particularly richly furnished with burial goods of copper and gold, two jadeite hatchets appear as local reworkings.

For many other materials, a local origin can be assumed from their natural occurrence, for example, for the saltwater molluscs *Spondylus* and *Dentalium*, the shells of which were used in the fabrication of jewellery. Their nearest geographical occurrence is in the Aegean (Renfrew/Shackleton 1970; Shackleton/Elderfield 1990). Recent studies of the gold finds of Varna I render the use of placer deposits likely, although their exact localisation is methodologically difficult. Recent discoveries of alluvial placers render a regional supply from the foothills of the Western Balkan, Rhodope, and Strandzha ranges conceivable (Leusch et al. 2015; 2016).

The Transition to Early Bronze Age

The end of the Chalcolithic tell settlements on the Lower Danube at the turn of the 43rd to the 42nd cent. BC, comes along with a transformation in the use of resources. The region of the lower course of the Yantra river, where comparative studies of the prehistoric settlement dynamics was studied (Krauß 2006) is archaeologically particularly well studied. While the settlements of the Neolithic and Chalcolithic are located preferably on different types of chernozem, the agricultural quality of arable land no longer plays a significant role in the location of sites during the Transitional and Early Bronze Age periods (Krauß 2006, 219–231). Many of the sites on the lower course of the Yantra river are distinctively smaller during this period and, in contrast to the Chalcolithic, do not display a distinct settlement organisation. In many cases, it seems that the settlements existed only for short periods. Both factors, the minor importance of soil quality in the location of settlements, and a reduced stability could be signs of increasing animal husbandry and reduced significance of agriculture during the period from the 42nd cent. BC onwards in the catchment area of the Yantra river. This raises the question about the causes of this change. In academic literature, the hypotheses of the invasion of a new population (Yamnaya culture) from the North Pontic steppes has been much discussed and later a climatic change (Todorova 1993; 2002; 2016). An alternative explanation for the end of the tell cultures at 4200 calBC on the Lower Danube could also be the outbreak of an epidemic, as such are now palaeogenetically confirmed for central Europe during the 3rd mill. BC (Valtueña et al. 2016). The acquaintance with new kinds of livestock in the Eurasian steppes (equine domestication) also presents a hotbed for the emergence of novel parasites. The densely settled regions of the Lower Danube, directly adjacent to the northern Pontic steppes, may well have been particularly vulnerable to new pathogens.

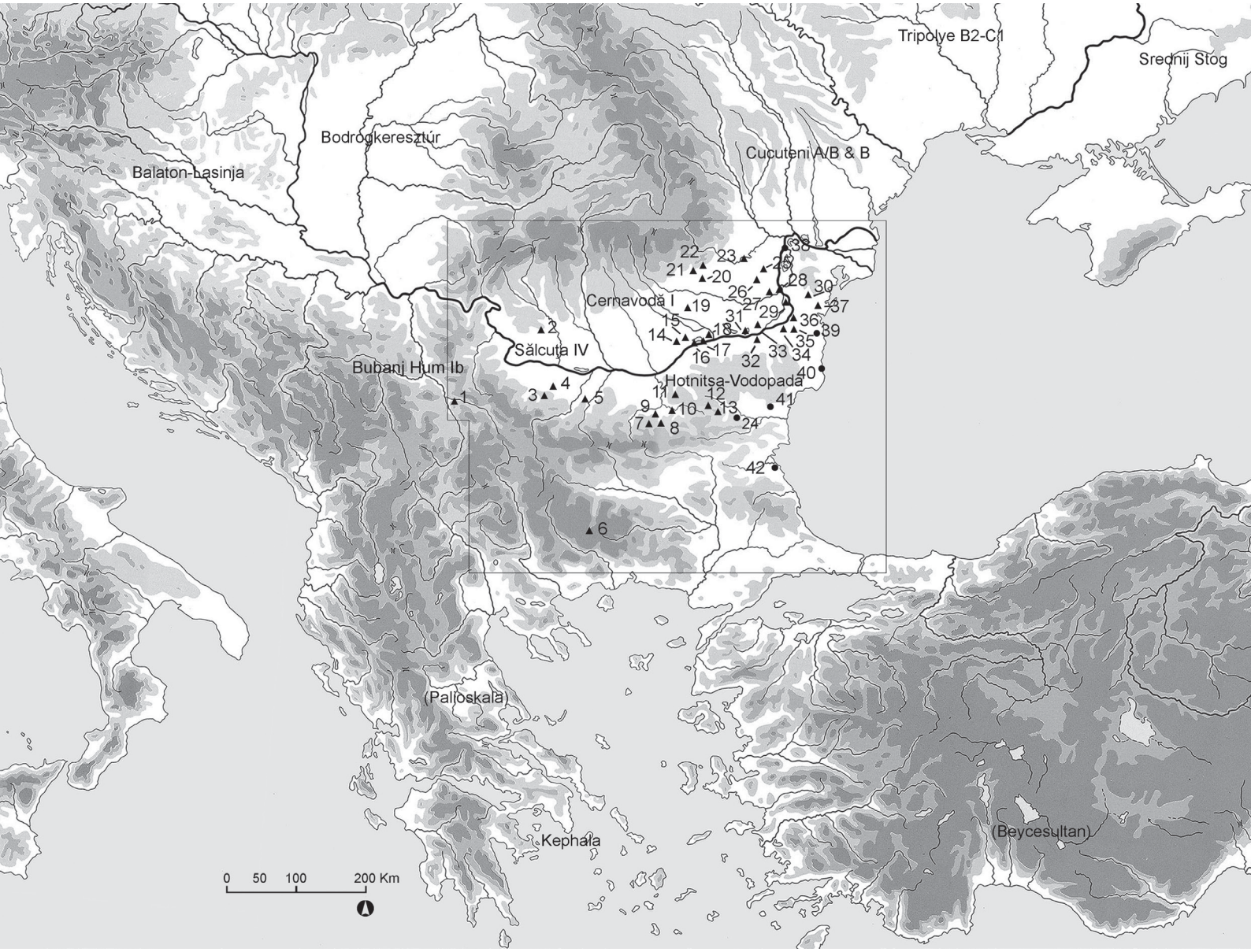

Fig. 21. Map of so called 'Post-Chalcolithic' settlement in the eastern Balkans (42nd – 37th cent. BC). Settlements (triangles): 1 Bubanj, 2 Sălcuţa, 3 Krivodol, 4 Galatin, 5 Telish, 6 Yagodina cave, 7 Shemshevo, 8 Kachitsa, 9 Hotnitsa-Vodopada, 10 Dzhulyunitsa, 11 Koprivets, 12 Pevets, 13 Ovcharovo-Platoto, 14 Greaca, 15 Căscioarele, 16 Chirnogi, 17 Olteniţa-Renie, 18 Ulmeni-Tăuşanca, 19 Moviliţa, 20 Gherăseni, 21 Pietroasele, 22 Sărata Monteoru, 23 Râmnicelu, 25 Lişcoteanca-Olarului, 26 Însurăţei-Popina, 27 Borduş, 28 Hărşova, 29 Ghindăreşti, 30 Cheia, 31 Călăraşi-Gradiştea, 32 Oltina, 33 Roşeti, 34 Malu Roşu, 35 Medgidia, 36 Cernavodă, 37 Gura Dobrogei. Graves (dots): 24 Smyadovo, 38 Brăiliţa, 39 Anadolköy, 40 Durankulak, 41 Reka Devnya, 42 Alkadi Cheiri (after Илчева 2009 and Meyer 2008 with additions).

The situation in western Bulgaria, Oltenia, and the Central Balkans, the region of the former KSB I complex, is rather different. Some of the tell settlements (Telish, Galatin, Krivodol, Sălcuţa, Bubanj) still continued to exist into the 38th cent. BC. So-called 'Scheibenhenkel' decoration appears on pottery, which may be understood as a common stylistic feature of various groups within the Carpathian basin (Bodrogkeresztúr; Hunyadihalom). Massive copper implements such as axe-adzes of the Ariușd, Jászladány, and Tîrgu-Ocna types in the area between the southern arc of the Carpathians and the Balkans only appear in large quantities in the west, while in the region of the previous KGK VI complex there are only a few scattered examples of these artefacts (Vulpe 1975, 35–51; Todorova 1981, 46–49). Generally, it seems that the production of heavy implements shifted to the

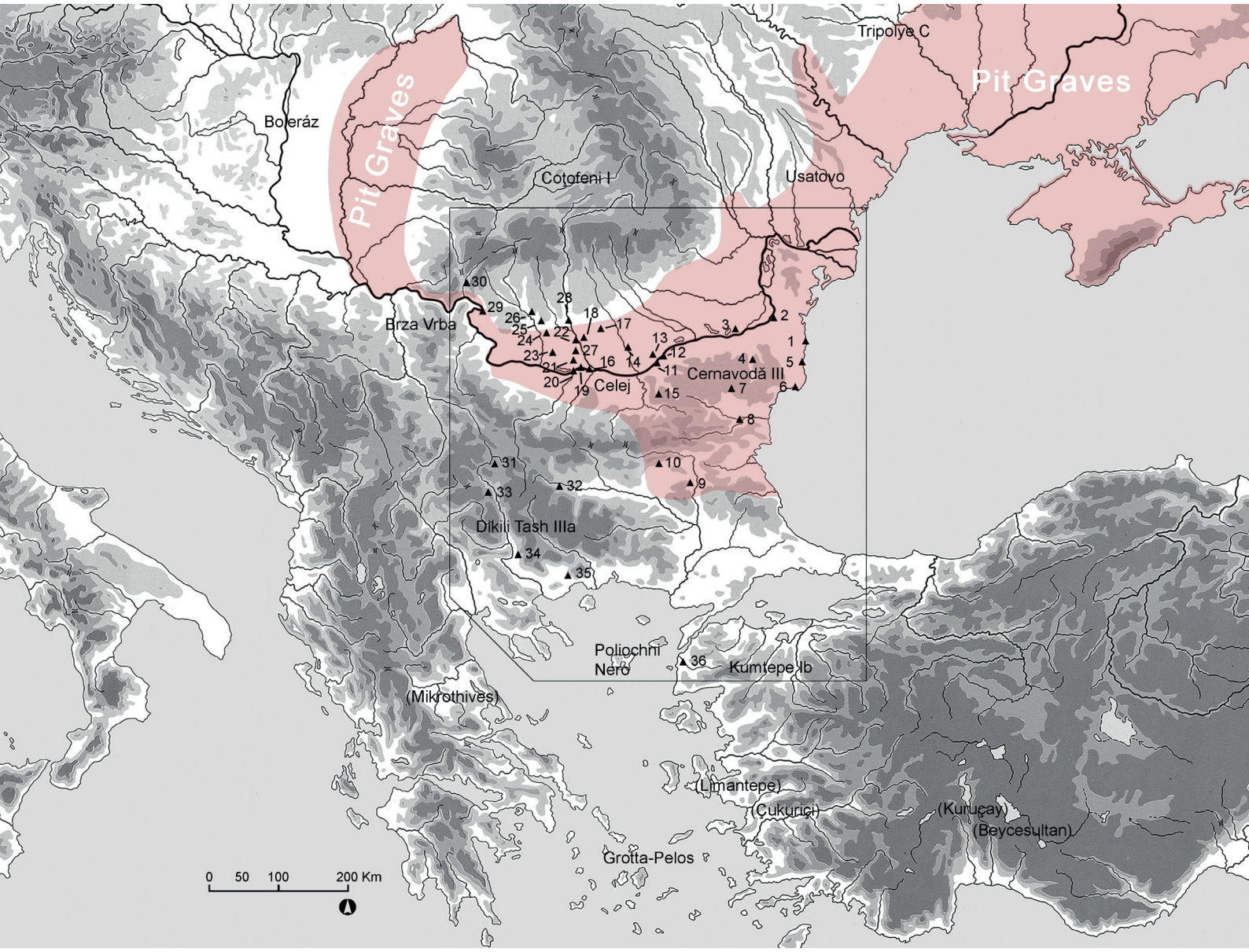

Fig. 22. Map of so called 'Proto-Bronze Age' settlement in the Eastern Balkans (36th – 33rd cent. BC). Settlements: 1 Tuzla, 2 Cernavodă, 3 Călăraşi, 4 Kragulevo, 5 Durankulak, 6 Kavarna, 7 Mirovtsi, 8 Dalgopol, 9 Drama, 10 Karanovo, 11 Slobozia, 12 Malu Roşu, 13 Ghizdaru, 14 Măgura Buduiasca, 15 Dzhulyunitsa, 16 Celej, 17 Dobroteşti, 18 Draganeşti, 19 Siliştioara, 20 Orlea, 21 Vădastra, 22 Fărcaşu de Sus, 23 Locusteni, 24 Cîrcea, 25 Şimnic, 26 Almaj, 27 Vladila, 28 Piatra, 29 Vajuga-Korbovo, 30 Băile Herculane, 31 Radomir Vahovo, 32 Yunatsite, 33 Vaksevo, 34 Sidirokastro, 35 Dikili Tash, 36 Kumtepe (according to the data of various authors in Roman/Diamandi 2001 with additions).

Carpathian basin with the end of tell settlements in the KGK VI region.

At this point, at the latest from the 40th cent. BC onwards, the Cernavodă I Group appears in the region of the Danube delta to eastern Thrace (Meyer 2008). Even if the eponymous find site of Cernavodă in the Romanian Dobrogea (Dobrudzha) may be considered as a tell, the Bulgarian sites (Hotnitsa-Vodopada group) have mostly just a single habitation layer and were only briefly settled (Илчева 2009) (*fig. 21*). While the pottery of Cernavodă I certainly adopts individual forms from the Chalcolithic, its fabric with the temper of crushed mussel and snail shells is, however, clearly different from earlier pottery. The burial customs during the so-called 'Post-Chalcolithic' in Vasjov's sense are generally unclear, as the Chalcolithic cemeteries cease completely in eastern Bulgaria in



Fig. 23. Finds from a tumulus grave of the Ochre Grave Culture from Celei, Jud. Olt (Oanţă-Marghitu 2013, 189, Kat. Nr. 10.1).

the course of the 43rd cent. BC. Only a single grave from Reka Devnya underneath a reconstructed hill embankment might belong to this period on account of its burial goods (Parzinger 1998, 125; seen differently by Lichardus 1993, 63–65). Due to the poor inventory of settlements and graves, the metal production of the 'Post-Chalcolithic' is also less well studied. Different objects of pure copper were found in the grave of Reka Devnya: a long, narrow chisel, a flat hatchet with a fanlike outward-swinging edge, a T-shaped implement with two bore holes in its head, a folded, stiletto-like, broad wire, and nine small beads. To this might be added 32 small golden rings which, based on their small diameter, might also be considered as beads. Further graves to be linked to Cernavodă I (Brăiliţa; Anadolköy) are uncertain in their absolute dating (Krauß et al. 2016, 288). However, two graves from the area of the settlement at Akladi Cheiri have to be included to this time horizon. Yet, the burials are not related to the settlement of the Late Neolithic-Chalcolithic, as they clearly postdate them. Two radiocarbon dates for the male bones from Grave 1 (Lyon-6027: 5115±35 BP; Lyon-7484: 5110±35 BP) fall within the aforementioned plateau of the calibration curve at the turn of the 40th cent. to the 39th cent. BC (Tsirtsoni 2016, 51).

For the following period between the 36th to 33rd cent. BC, the so-called 'Proto-Bronze Age' in Vasjov's terminology, only a few details are available (*fig. 22*). This is a period in which arsenical copper establishes itself comprehensively across the Balkans (Vajsov 2002, 163–172). The metal items of this period comprise only small-sized, triangular daggers and a few pieces of jewellery. Among the latter the spiral-rings, or 'Lockenringe' are to be noted, which consist of arsenical copper, gold, and also silver (*fig. 23*), which is the first appearance of this metal in the eastern Balkans.[4]

The radiocarbon date of charcoal contained within a block of slag (MAMS-24609: 4437±31 BP) from the site of Kurucheshme in Medni Rid may be assigned to the verge of the Early Bronze Age. The date falls within a further marked plateau of the calibrations curve, which covers the entire 32nd cent. BC. In the eastern Balkans, this phase is absolutely unspectacular with respect to metal production. There is not a single archaeological find context to provide substantial details regarding settlements at the transition to the Early Bronze Age. Certainly, arsenical copper still belonged to the common materials for the region well into the

4 Regarding the applications of silver foil in the form of a boar's tusk allegedly dating to the 5th and 4th millennia BC (Hansen/Helwing 2016, 47), it might be argued that only from the Bronze Age onwards there are truly secure contexts known: Emen (Николова/Ангелов 1961) and Panayot Hitov (Konova 2018).



Fig. 24. Two oxhide copper ingots from the Regional Historical Museum of Varna believed to be found in the vicinity of Kamen (Тодорова 2011, fig. 116).

Middle Bronze Age. For instance, the metal production from tell Dipsis (Ezero) in Thrace, which should be placed in the 32nd cent. BC consists merely of needles, small awls, and chisels, as well as rare sheet daggers and only two flat hatchets (Черних 1979). The demand for the production of these small implements could certainly have been met by local sources.

A View on Later Periods

With the introduction of tin bronze metallurgy, the copper deposits of the Balkan region appear to have become of merely secondary importance. In view of the very rich copper deposits of Bulgaria and Romania, this is quite astonishing. It is possible that the tin required for the production of bronze was not readily available. This would speak against the exploitation of the minor tin occurrences in Serbia (Huska et al. 2014). While the metal production of the Early Bronze Age was still entirely based upon arsenical copper, in the course of the Middle Bronze Age, ever more tin bronze objects appear in find contexts. During the Late Bronze Age, the eastern Balkans appear as a mediator in the circulation networks of raw copper in the form of so-called oxhide ingots (*fig. 24*). This ingot form is completely foreign to the region and can be regarded as an indication for the copper supply that no longer relied on regional sources, but rather on the well-known deposits of the Mediterranean (especially Cyprus) (Athanassov et al. 2020). Gold, in contrast, continued to be locally produced and in the Late Bronze Age even by mining for primary gold at Ada Tepe in the Rhodope mountains (Popov et al. 2011; Popov/Jockenhövel 2017).

During Early Bronze Age once again tell settlements appear at least in Thrace for a few centuries but hardly any evidence for satellite settlements has been identified. In addition to tells circular ditch enclosures of the Early and Middle Bronze Ages were discovered during the last few years,

for which a ritual use has been suggested (Leshtakov 2006). During Early Bonze Age cemeteries with burials in crouched position are most common. In the course of Middle Bronze Age, tell settlements finally disappear permanently, and the Late Bronze Age is characterised by a dispersed settlement system with little in the way of marked centrality. At the transition from Middle to Late Bronze Age cremation generally prevails in the burial customs. Metal finds are mostly known from hoards, the consistency of which demonstrates contact with the Aegean Bronze Age on the one hand and with the Bronze Age groups of the Carpathian basin on the other hand. It is difficult to identify any local component, as even those metal shapes described by colleagues as 'indigenous' seem to emulate either Aegean or Carpathian examples. Often, bent or broken swords appear in the hoards, the function of which cannot be commented on due to a general lack of knowledge of the local cultural sphere (Athanassov/Krauß 2015). Other common metal types of the Late Bronze Age are spearheads, double axes, socketed axes, and sickles, thus objects which may have served both as weapons and tools, and also as metallic equivalents of value in societies with pre-monetary exchange systems. Cast forms likewise deposited in hoards (Pobit Kamak) provide information about local production of these objects. Nevertheless, the question arises once more as to whether either local copper ore, imported raw copper, or recycled scrap metal was employed. The incomplete knowledge of the settlement structures of the Late Bronze Age in the eastern Balkans alone renders an argument for the use of local metal deposits problematic.

In the 1st mill. BC at the latest on both sides of the Balkan range and the Lower Danube, cultural groups appear which can be partially identified with the historically transmitted tribes of the Thracians. It may be assumed that the extensive metallurgical and toreutic production of the Iron Age could once again (or perhaps even further continue to) cover its raw material needs from local deposits. Nevertheless, the recycling of metal evidently played a large role. Overall, however, the metal production of the Thracian period must be considered to be, comparatively speaking, poorly researched. With the beginning of the Greek colonisation in the 8th cent. BC an increased mining activity in the ore mining district of Medni Rid is observed, the impact of which must have erased for the most part traces of prehistoric mining. Almost all traces of the pre-industrial mines in south-eastern-Bulgaria documented in this project could be identified with mining activity initiated and directed by the Greek colony of *Apollonia Pontica* (modern Sozopol).

By comparison of the chemical signatures of Chalcolithic artefacts with the deposits, and moreover, the remains of metal production from the settlement of Akladi Cheiri, copper mining in the Medni Rid from the 5th mill. onwards is nevertheless securely established. A continuous use of these deposits until the historical era could, however, not be proven within this project. More likely, new mining activities in different historical epochs were relying on their own traditions and were not technologically related to previous mining phases. One particular chapter in the mining history of Medni Rid is the uranium mining during the Soviet era. The landscape and transport infrastructure of our research area is above all marked by the relics of this final mining period. The present book, hence, documents only one period of the long history of exploitation in this ore district with a clear focus upon the mining of copper ore and minerals.

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René Kunze and Ernst Pernicka

The Beginning of Copper and Gold Metallurgy in the Old World

Keywords: Black Sea, Copper Age, metallurgy, copper, gold

Introduction

The complex knowledge involved in making use of available raw materials characterises prehistoric societies more than any other technological innovation. This knowledge comprises not only the appropriation of, i.e. the exploitation of, the raw material, but also the many various processing techniques involved in producing the desired product. Besides gold and silver that were largely used for prestige and symbolic objects, copper was the main material used for the production of tools, weapons and jewellery.

The technological innovation resulting from the introduction of copper also represents one of several aspects that favoured fundamental social changes towards hierarchically organised societies that can mainly be recognised by burial customs and by architecture (Klimscha 2013; Bánffy 2010; Levy 2007). A clearly segmented chain of production (mining, processing of raw materials, transfer of semi-finished products and finished objects) and the rising demand for metals required new ways of interaction between producers and consumers; regular communication within and between communities was, therefore, indispensable (Wallerstein 2000). The trade of raw materials re-organised itself by the rise of new and partly overlapping networks. The impact on the societies has so far not been investigated in detail, especially in view of the fact that in South-East Europe those complex systems with long-distance contacts seem to disappear at the transition into the Early Bronze Age during the 4th mill. BCE as indicated by the drastic reduction of the number of archaeological sites (Parzinger 1998). None of the so far suggested explanations, including technological problems (depletion of easily accessible deposits), political and social upheavals or climate change have so far been widely accepted (Parzinger 1998; Strahm 2010; Klimscha 2014).

Since the development of metallurgy and the resulting complex system of exchange and communication cannot be treated as an isolated phenomenon, we will first provide a short overview of the development of copper metallurgy in the Near East and in South-East Europe. Some of the earliest and most innovative centres of early metallurgy are located in the Balkans, Anatolia and the eastern Pontic region including the southern Caucasus (*fig. 1*). There exists a substantial number of publications on this topic, so this summary is only intended to provide the background for the detailed presentations of the results of the project.

The Beginnings of Copper Metallurgy in South-West Asia

According to present knowledge, the beginnings of metal usage can be traced to the Near East in the Fertile Crescent area, which stretches from the Levant over the piedmont of the Taurus mountains in eastern Anatolia to the Zagros mountains in northern Iraq and western Iran. They date to the transition period into sedentary life, which most likely began in the Natufien period, around the 13th mill. BCE. A characteristic feature of these changes is the rising interest for intensely coloured materials that are clearly recognisable in

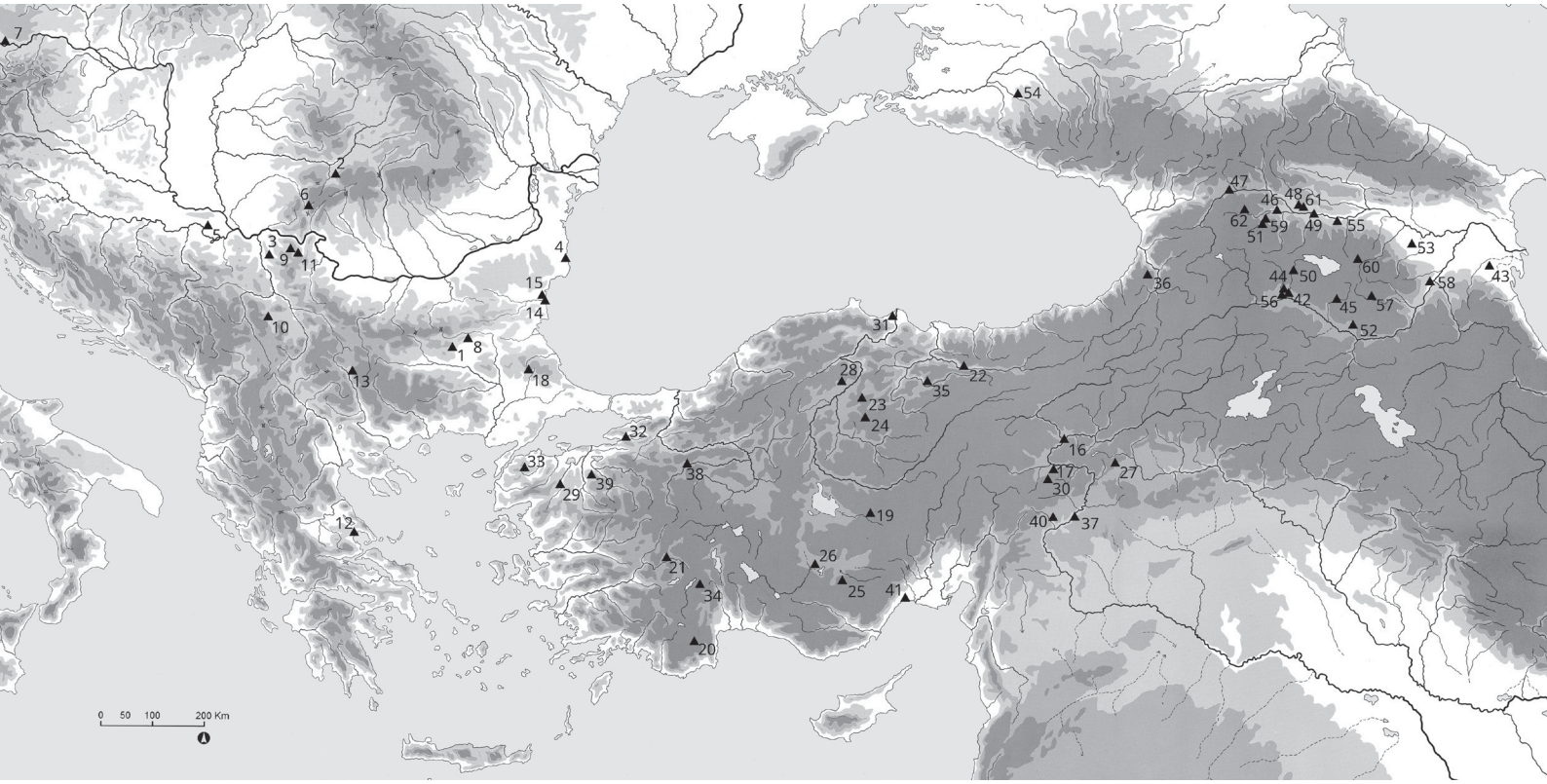

Fig. 1. Map of the sites mentioned in the article: 1 Aibunar, 2 Balomir, 3 Belovode, 4 Durankulak, 5 Gomolava, 6 Gornea, 7 Kamnik, 8 Karanovo, 9 Majdanpek, 10 Pločnik, 11 Rudna Glava, 12 Sesklo, 13 Slatino, 14 Usoe II, 15 Varna, 16 Altınova, 17 Arslantepe, 18 Aşağı Pınar, 19 Aşıklı Höyük, 20 Bağbaşı, 21 Beycesultan, 22 Büyük Güllücek (Kaletepe), 23 Çağşak, 24 Çamlıbel Tarlası, 25 Can Hasan II, 26 Çatal Höyük, 27 Çayönü Tepesi, 28 Derekutuğun, 29 Doğancılar, 30 Hallan Çemi, 31 Ikiztepe, 32 Ilıpınar, 33 Kızıl Tepe, 34 Kuruçay, 35 Kozlu, 36 Murgul, 37 Nevalı Çori, 38 Orman Fıdanlığı, 39 Serçeören Köy, 40 Yarim Tepe I, 41 Yumuktepe, 42 Aknashen-Khatunarkh, 43 Alikemek-Tepesi, 44 Aratashen, 45 Areni-1, 46 Arukhlo, 47 Berikldeebi, 48 Boyuk Kesik, 49 Gargalar Tepesi, 50 Karashamb, 51 Khramis Didi-Gora, 52 Kültepe I, 53 Leyla-Tepe, 54 Maikop, 55 Mentesh Tepe, 56 Metsamor, 57 Nerkin Godedzor, 58 Qarakepektepe, 59 Sakdrisi, 60 Sotk, 61 Soyuq Bulaq, 62 Trialeti.

nature. In the preceramic settlements in this region appear small implements made of hematite, carnelian, turquoise, and malachite, which were worn as ornaments similar to objects made of bone, antler or shells. The first evidence for the use of copper minerals for the production of beads dates to this period. It is contemporary with other green stone materials and might be interpreted as a symbol for the burgeoning green of crops in springtime and as well as a symbol for eternal fertility (Bar-Yosef Mayer/Porat 2008; Solecki et al. 2004). This signifies the beginning of a tradition that identifies green and blue colours with special symbolic values, which continues into the present as ethnographic studies have shown (Mershen 1989) and which is particularly present and well-known in the Orient. Although this symbolism was not yet related with metallurgy it is highly likely that those materials were occasionally exposed to fire and that the conspicuous colour changes of copper minerals exposed to intense heat were observed. The green malachite ($Cu_2[(OH)_2|CO_3]$), the most abundant oxidised copper mineral, becomes black when fired due to the formation of tenorite (CuO) or red under more reducing conditions due to the formation of cuprite (Cu_2O).

At Hallan Çemi in present day eastern Turkey first indications of intentional collection of pieces of copper ore are known in the Pre-Pottery Neolithic A (PPN A), around 9,500 BCE (oxidic and/or carbonatic secondary copper minerals), which had apparently been pounded to obtain colour pigments (Rosenberg 1995, 81; Zimmermann 2011, 297). In the Early Neolithic, especially during

PPN B, the first secure evidence for the processing of copper metal appears in the form of cold-hammered objects, mostly in the form of beads or small pendants (Yalçın 2000a, 18–20). They consist entirely of native, i.e. naturally occurring, copper metal. Therefore, this cannot yet be regarded as metallurgy proper but only as the working of metal but employing its specific properties like its ductility. Nevertheless, metallurgical techniques, such as annealing (heating to several hundred degrees Celsius over a length of time), were already being applied. It was apparently already recognised that the deformation of metal results in increased hardness and brittleness so that it tends to form cracks upon hammering. Annealing leads to recrystallisation of the metal and thus removes the stacking faults that make it brittle and renders it ductile again. Such practice has been observed at several sites like Çayönü Tepesi, Aşıklı Höyük, Nevalı Çori, which date into the first half of the 8th mill. BCE, and later also at Çatal Höyük (Birch et al. 2013; Özdoğan/Özdoğan 1999; Yalçın/Pernicka 1999; Esin 1995). In the late 8th mill. BCE similar finds appear outside this core region from central to east Anatolia, like at Tell Ramad in south-western Syria (Golden 2009) and at Ali Kosh in south-eastern Iran (Pigott 1999; Hole 2000) and around 6,000 BCE reach Mehrgarh in Pakistan (Kenoyer/Miller 1999; Moulherat et al. 2002). Obsidian from distant sources has been found at two of these sites at least (Wertime 1964; Cauvin et al. 1998), indicating not only the wide distribution of certain materials but also the transfer of metallurgical knowledge over long distances.

The innovative step of the ability to create new and desirable forms of a material by applying heat[1] certainly forms the starting point for true extractive metallurgy, i.e. the intentional transformation of ores into metal. Claims for an incipient extractive copper metallurgy in Anatolia[2] were based on smelting slags and cast objects (pins with rolled heads, a chisel and a flat axe) and remains of a chimney in a house of the stratigraphic layer XVI of the tell site of Yumuktepe in the centre of the modern city of Mersin in south-eastern Anatolia dating to the transition of the 6th to the 5th mill. BCE (Yalçın 2000a, 21 f.; 2000b; Caneva et al. 2012, 356; Zimmermann 2011, 298).[3]

A lead bracelet from Yarim Tepe I was similarly suggested as indirect hint towards extractive metallurgy (Merpert/Munchaev 1977; 1987). Since lead as a native metal is extremely rare in nature (certified occurrences are only known in Sweden and North America), it can be assumed that already in the early Hassuna period lead metal may have been produced from lead ores, perhaps unintentionally. This does not necessarily mean that copper could be produced this way as well, because, unlike copper, lead forms relatively easily in an open fire from lead ores (Tylecote 1962). However, the observation that a rather soft and fragile material like lead ores can be transformed into a heavy ductile material like lead metal may have guided the way towards more experimentation and eventually to the intentional production of copper from ores (Krysko 1979). Furthermore, the discovery that metals can be melted and thus be cast into any desired shape is more easily imaginable with lead, whose melting point is 327°C, as opposed to copper, which melts at 1083°C.

The most convincing evidence for the extractive metallurgy of copper does not derive from the core region of early copper processing

1 R. Maddin and co-workers as well as Ü. Yalçın identified so-called recrystallisation twins by metallographic investigations of several finds of native copper from Çayönü Tepesi (Maddin et al. 1991, 379) and Aşıklı Höyük (Yalçın 2000a), which only form on annealing after deformation of the copper; clear evidence for a kind of 'anthropogenic' pyrotechnology. E. Geçkinli disagreed with this interpretation and suggested a natural geological process for this observation (cf. Esin 1995, 66).

2 There was a long and controversial discussion on the material and the production technology of the mace head of Can Hasan II (ca. 6,000 BCE) as well as the correct interpretation of heated materials from Çatal Höyük that were interpreted as metallurgical slag. Both were considered by some as indications of extractive metallurgy in the 6th mill. BCE while others raised doubts about their interpretations (for a summary see Yalçın 2000b, 116 f.). Meanwhile it has become clear that both sites do not provide evidence for extractive metallurgy (Yalçın/Pernicka 1999; Radivojević et al. 2017).

3 The stratigraphic context of the 'tripartite building […] of specialized coppersmiths' (Caneva et al. 2012, 356) was dated with radiocarbon. I. Caneva and co-workers cite possible date ranges of 4,910–4,720 and 4,730–4,445 BCE (Caneva et al. 2012, 356) but it is unclear from where the sample actually derives.

but from the periphery, namely from Ali Kosh and Tepe Ghabristan in Iran (Caldwell 1968; Majidzadeh 1979; Frame 2004) and from Belovode in Serbia (Radivojević et al. 2010) and dates to the 5th mill. BCE. In the transit region of north-western Anatolia only very few Chalcolithic metal objects have so far come to light. This may be due to the state of research, in that, according to H. Parzinger, the Chalcolithic is the least known period of Anatolian prehistory (Parzinger 2005, 59). It may be worth mentioning, even if not directly related to metallurgy, that a large number of high quality malachite beads and associated chalcolithic workshops were found at Aşağı Pınar in Turkish Thrace (layers 4–2, ca. 5,200–4,700 BCE), which show close parallels with the cultural sequence at Karanovo in eastern Bulgaria (Özdoğan/Parzinger 2000, 85–88). The only securely dated indications for extractive pyrometallurgy in this region are an awl and a pin with a double-spiral head as well as possibly a crucible from Orman Fıdanlığı near Eskişehir (phase VII) dating to the second half of the 5th mill. BCE (Schoop 2005, 278; Ay-Efe 2001, 139, 145, 154 fig. 8).[4] Further metal finds, e.g. from Kuruçay, Beycesultan, Bağbaşı or the newly excavated site Çamlıbel Tarlası date towards the end of the Anatolian Chalcolithic, i.e. the first half of the 4th mill. BCE (Schoop 2011; Zimmermann 2011, 304; Ay-Efe 2001, 139; for the general background see Schoop 2005, 149–184).

According to the present state of research and in view of the rather limited number of metal objects from the 5th mill. in north-western Anatolia it is not possible to draw any conclusions concerning the socioeconomic conditions of the cultural groups and the possible relation to copper metallurgy. Only towards the end of the Anatolian Copper Age in the middle of the 4th mill. BCE some aspects of the technological and social structures become visible. At Çamlıbel Tarlası near Boğazköy several pits in the ground used for smelting were documented in both the seasonally (Çamlıbel Tarlası I) and the permanently occupied (Çamlıbel Tarlası II) settlement (Schoop 2011, 56–59, fig. 6).[5] A copper mineralisation with some indications of surface mining could have provided the malachite copper ore (Schoop 2011, 57, fig. 7; Rehren/Radivojeviç 2010, 215). Furthermore, hoards of tools together with semi-finished and finished implements and jewellery were discovered at several sites, e.g. in layer 34 at Beycesultan near Çivril (Zimmermann 2005, 194–196; 2006, 256). An important site for possible contact between north-western Anatolia and South-East Europe is Ilıpınar near Bursa south-east of the Marmara Sea. Several burials dating to the middle of the 4th mill. BCE with numerous grave goods were found in Phase 4 (Roodenberg et al. 1990; Roodenberg 1995). Especially noteworthy are rhomboid blades that show parallels to daggers of the developed Chalcolithic of the Balkans (Type Bodrogkeresztúr). Geochemical analyses suggest, however, that local metal sources were used to produce these blades[6] and that the cultural relations to the Balkans may have been weaker than is suggested by metal typology (Zimmermann 2006, 254 f.).[7] Furthermore, anthropomorphic clay figurines were found which are similar to other western Anatolian sites like Kuruçay Höyük that exhibit distinct similarities to contemporary figurines of the Balkans (Hansen 2014, 275, 278) as well as at Ikiztepe near Bafra on the northern Black Sea coast. The chronology of this site has been discussed controversially (see for example Parzinger 1993, 237 f.; Thissen 1993, 215–218; Schoop 2005, 307–322; Zimmermann 2007, 30) but several elements of pottery decoration and anthropomorphic clay fig-

4 Four more copper objects (two flat axes, a dagger, and a pin) derive from Büyük Güllücek (Kaletepe) near Alaca that are considered to date into the first half of the 5th mill. BCE (Schoop 2005, 43 f.). This date has as yet not been generally accepted (Parzinger 1993, 235).

5 In the third and fourth phases of Çamlıbel Tarlası the find assembly changed: Smelting pits and copper ores disappear but smelting slag and crucible fragments were found. Schoop interprets this without detailed arguments as 'Veränderung in der metallurgischen Praxis [ohne] dieses Muster chronologisch zu werten' (Schoop 2011, 59, 63).

6 Although the blades consisted of copper with high arsenic contents, F. Begemann and colleagues who analysed these objects concluded that the arsenical copper should be considered as an unintentional alloy (Begemann et al. 1994, 205). Furthermore, they observed that the ore sources were different from contemporary arsenical copper in the Balkans (Begemann et al. 1994, 208).

7 There is some typological relation of the earlier pottery from Ilıpınar with the Karanovo IV phase of the contact zone in Turkish Thrace (Aşağı Pınar) but there is no settlement of this period at Ilıpınar (Parzinger 2005, 60 f., 64).

urines were compared with the Chalcolithic layers of Aşağı Pınar and the Varna cultural complex of the late 5th mill. BCE (Ivanova 2013, 254 f., fig. 7: 8; Thissen 1993, 217). Further parallels to Varna are suggested by some metal types like ring idols, ornamental discs and flat axes consisting of copper with high arsenic contents (Parzinger 1993, 237). In addition, several blades correlate with style and chemical composition the stratigraphically secure objects from Ilıpınar as concerns style and chemical composition (Zimmermann 2008, 471 f.).[8]

Further research is required to identify the geological sources of the metals of the 5th and 4th mill. BCE and the position of metallurgy within the social organisation of this period (see a critical review by Schoop 2011, 53 f.). Although numerous copper mineralisations were identified in this region including all kinds of copper ores and even native copper, their exploitation can so far only be documented from the 3rd mill. onwards (Pernicka et al. 1984; Seeliger et al. 1985; Wagner/Öztunalı 2000).[9] Together with other raw materials, like obsidian, gold, and silver, a diversified handicraft can be reconstructed in the 3rd mill. BCE resulting in metallurgical centres like in the Altınova (Yalçın 2000a) or at Derekutuğun (Yalçın/İpek 2016). While Chalcolithic remains of metal production are mainly found within settlements, these activities were moved out towards the sources of raw materials during the Bronze Age. The subsequent steps of the chain of metallurgical processes (casting, alloying, smithing, finishing) remained in the settlements. Distances between copper mining and settlements could become quite large (e.g. at Çamlıbel Tarlası) but some settlements are also found near the mines like Derekutuğun.

Most chalcolithic metal objects consist of arsenical copper resembling similar practices in the southern Caucasus. Traditionally it was assumed that this alloy was largely produced unintentionally, possibly only by selection of certain arsenic-bearing copper ores. The reason was that native arsenic is quite rare and it is technically difficult to melt it together with copper due to the fact that arsenic is not only highly volatile but actually vaporises at 613°C, much lower than the melting point of copper at 1083°C. It was discovered only recently that it was possible to enrich copper with arsenic by the addition of speiss, a mixture of iron arsenides that can be produced by removing sulfur by extended heating (the metallurgical term is roasting) of arsenopyrite (Thornton et al. 2009; Rehren et al. 2012). The whole context at Çamlıbel Tarlası suggests that, in the 4th mill. BCE, metallurgy as well as agriculture were practiced intermittently by the whole community without significant specialisation (Schoop 2011, 63). It is, however, not clear if metal production only served the needs of the community or if it served a wider network as suggested by the presence of flint and shells from external sources.

In sum, there are indications for a more or less regular exchange of materials and most likely also technological knowledge between north-western Anatolia and south-eastern Europe in the 4th mill. BCE while there is little comparable evidence for a similar exchange in the 5th mill.

Early Copper and Gold Metallurgy in the Southern Caucasus

The geographical area south of the Greater Caucasus mountain range[10] belongs to a hitherto seldom regarded (but nevertheless important) region

8 Despite the obvious stylistic parallels between Ilıpınar and Ikiztepe these should not be overemphasised.

9 In central Anatolia the copper deposits of Derekutuğun and Çağşak show clear evidence of Bronze Age mining (Wagner/Öztunalı 2000, 32 fig. 2, 50 f.; Yalçın/İpek 2016) but in north-western Anatolia mainly Greek and Roman mining has been documented (Wagner/Öztunalı 2000, 33). It has been suggested that mining was already practiced at Aşağı Pınar but no evidence has been presented (Özdoğan/Parzinger 2000, 83). There are several mining sites for copper in the Troad that would be good candidates for early metal production (e.g. Kızıl Tepe [Balya] and Doğancılar) but they were also worked in later periods that largely destroyed the evidence of earlier workings (Wagner/Öztunalı 2000, 35–40; Wagner et al. 1985). The remains of ancient mining at Serçeören Köy in western Anatolia look rather old and seem to be promising for further research (Wagner et al. 1989). Only in northern and north-eastern Anatolia evidence for late 4th mill. mining has been identified (Murgul, Kozlu; see Wagner/Öztunalı 2000, 46, 49 f.).

10 The term 'southern Caucasus' (often also referred to with the outdated and politically motivated term 'Transcaucasus') characterises the geographical area south of the Greater Caucasus extending to the Taurus mountains (cf. Bobokhyan 2009, 91).

for early metallurgy and the respective trade relationships due to its proximity and contact with the Near East (Kavtaradze 2013). Research on Bronze Age and Iron Age civilisations is often emphasised,[11] while the preceding periods receive significantly less academic attention, creating a considerable research desideratum (Pizchelauri/Mamaiashwili 2004; Stöllner et al. 2010). Only recently has structured research on this subject been conducted, albeit often regionally limited to individual research groups. A preliminary overview of the current research status should therefore be given at this time.

Numerous secondary copper ore lumps and objects – mostly cold-hammered copper beads and sheets as well as small 'tools' – were documented from several find contexts dating to the early 6th mill. BCE in the southern Caucasus. These can mostly be characterised as settlement finds belonging to the Late Neolithic (Aratashen-) Shulaveri-Shomutepe horizon,[12] for instance Khramis Didi-Gora and Arukhlo in Georgia, Gargalar Tepesi in Azerbaijan as well as Aratashen[13] and Aknashen-Khatunarkh in Armenia (Kushnareva 1997, 23, 175; Kavtaradze 1999, 69; Hansen et al. 2012; Bobokhyan et al. 2014, 285). The hesitant beginnings of extractive metallurgy can be traced back to the beginning of the 5th mill. BCE with the transition of the (Aratashen-) Shulaveri-Shomutepe complex into those of the Early Chalcolithic (Adablur-) Sioni tradition. An impressive example of this can be seen at the site of Mentesh Tepe (late Sioni, ca. 4,300 BCE) near the Kura River in Azerbaijan. Here within the settlement was documented a virtually complete *chaîne opératoire*, i.e. a complex containing crushed copper ore (azurite), copper slag, a casting mould and numerous finished products (Courcier et al. 2012, 210–214; most recently Lyonnet et al. 2016). A similar situation was found in a Copper Age layer of the above-mentioned Aknashen-Khatunarkh in Armenia. Of particular interest here among the finds were a hammer/pestle made of basalt, remains of crushed copper ore and two crucibles (Badalyan et al. 2010, 199). Extractive metallurgy likely established itself quickly among the easily cultivated landscapes (especially in the river valleys of the Kura and the Araxes) but was only extensively practised from the early 4th mill. BCE onwards. Noteworthy settlements for early metallurgy along the Araxes are, for instance, Kültepe I in Nakhichevan and Alikemek-Tepesi in the Mugan Plain in southern Azerbaijan (Kushnareva 1997, 30–41). Both sites date to the beginning of the 5th mill. BCE (Sioni) and yielded numerous copper objects, including knives and beads, mostly made of pure copper but some with low contents of arsenic, which greatly resemble one another. A number of smelting pits and slag from Leyla-Tepe (Narimanov et al. 2007; Akhundov 2007, 108–119), moulds from Boyuk Kesik and Qarakepektepe as well as many knives, daggers and axes from Soyuq Bulaq and Berikldeebi mostly dating to the first half of the 4th mill. BCE (Tsopi phase) from the Middle Kura region are worth mentioning (see Courcier 2014, 594 f., 623–626).[14] Intentional alloying of copper with other metals appears from the middle of the 4th mill. BCE, or the beginning of the 'Early Bronze Age' context of the Kura-Araxes culture.[15] Despite the abundant natural occurrence of arsenic among copper ores in the southern Caucasus (see Kunze 2012, 95, 103), arsenic was, at that point, already being alloyed at high concentrations possibly in Teghut (4,000–3,700 BCE) and definitely already in Nerkin Godedzor and Areni 1 (mid 4th

11 For a comprehensive research history of prehistoric metallurgical practise during the Soviet and Post-Soviet era with additional references, see Kushnareva 1997; Courcier 2014, 582–584.

12 This characterisation goes back to Armenian chronology (cf. Avetisyan/Bobokhyan 2012, 18). The toponyms, 'Shomu-Shulaveri' or 'Shulaveri-Shomutepe Culture' are often used in Georgia and Azerbaijan.

13 Indications of copper processing from the early 6th mill. BCE (ca. 5,900–5,700 BCE) were documented in several contexts at the site of Aratashen (Badalyan et al. 2007, 52 fig. 8; Bobokhyan et al. 2014, 285 f.). Among these are copper ore, oxidised arsenic/copper beads and a bracelet made of solid copper (cf. Meliksetian et al. 2011).

14 Despite the focus on copper metallurgy, it should be mentioned that, alongside copper tools and jewellery a large number of gold and silver jewellery was found at many of the sites mentioned in the text (e.g. the burial mounds from Soyuq Bulaq; cf. Courcier et al. 2008).

15 The term 'Kura-Araxes' culture/level dates back to B. Kuftin and caught on mostly among researchers from the Caucasus, Russia and Germany. In the Anglo-American tradition, the term 'Early Transcaucasian Culture' is used along with 'Outer Fertile Crescent Culture' for scattered or individual cultures (cf. Smith 2015, 102).

mill. BCE) (Torosyan 1976, 60–65; Chataigner et al. 2010, 399; Bobokhyan et al. 2014, 286, 291 f.). This coincides with a change in the social system and in trade. While intercultural connections were infrequent during the earlier periods, the southern Caucasus region emerged as partner in a network of cultural connections, predominantly in the era from the middle of the 4th mill. BCE. The existence of interregional relations with cultures to the south as well as the Maikop culture to the north are, according to the current state of research, uncontested (Kavtaradze 2013; Pizchelauri 2012). In particular, the active interest of developed cultures in Mesopotamia and Iran in the southern Caucasus is largely based on the abundantly available metals (copper, gold, silver), although this may not have been the only reason (Munchaev/Amirov 2009, 46). This coincides chronologically with the completely developed techniques of copper metallurgy, emerging from new equipment and weapons made from various copper alloys and their corresponding specific regional forms (Courcier 2010, 84–87). Among settlements one observes an abrupt architectural change to large-scale, monumental structures, most of which appearing relatively unprotected in the plain tract. Pottery production changed to quite fine and extremely elaborate vessel types – the so-called Kura-Araxes Type – which spread as far as the northern Levant (cf. e.g. Kiguradze/Sagona 2003).

The precious metal gold, alongside with copper, played also an important part in the early metallurgy of the southern Caucasus region and was valued as one of the most important materials for ancient societies. Along with its less significant use as a metallic material it can be used to indicate prestige and wealth, in which societal developments and changes are reflected.

According to the current state of research, however, there exists a paradox in the Caucasian cultural region: While in the northern Caucasus many gold artefacts are known from the middle of the 4th mill. BCE – mostly of the Maikop Culture from the Late Chalcolithic/Early Bronze Age – only a few gold objects from the Middle Bronze Age (North Caucasian Culture) have hitherto been documented. Conversely, in the southern Caucasus, there are only a few gold artefacts known from the Early Bronze Age (Kura-Araxes-phase), among which are a couple finger rings and spiral rings as well as some beads from the princely tomb at Arslantepe (ca. 3,000 BCE) and a ring from Metsamor dating to the middle of the 3rd mill. BCE (Palmieri/Di Nocera 2000, 180; Khanzdyan in: Kalantaryan 2007, 72 Tab. 11.5). Along with the transition to the Middle Bronze Age (Martkopi-Bedeni/Trialeti cultural horizon) the number of gold finds increases rapidly (Sardaryan 1967, Tab. 45.1; Pizchelauri et al. 1994; Gambaschidze et al. 2001; Khanzadyan in: Kalantaryan 2007).

This situation is in stark contrast to the Early Bronze Age gold mining from Kachagiani as part of the Sakdrisi deposit in south-eastern Georgia near the Armenian border. Here a German-Georgian archaeological team has demonstrated that already during the transition period from the 4th to the 3rd mill. BCE gold was produced not only from secondary placers but also from primary gold deposits in the southern Caucasus (i.e. Hauptmann et al. 2010; Stöllner 2014). One possible interpretation could be that while gold was extracted in the southern Caucasus during the Early Bronze Age, it served rather as a trade good than as prestige good for the local nobility (Kunze et al. 2011). The east Armenian region of Sotk in the southern Caucasus is also worth mentioning alongside Sakdrisi in this context. This is the largest gold deposit in the southern Caucasus but so far only a Byzantine exploitation is proven by a radiocarbon date of wood from the mine (Kunze et al. 2011, 23; Wolf et al. 2013, 40 fig. 17). But there are a number of indications that an earlier exploitation is very likely: Numerous settlements of the 4th and 3rd mill. BCE were discovered in close vicinity of the deposit (Kunze et al. 2013; Wolf/Kunze 2014) and the general appearance closely resembles the setting of Sakdrisi.

Besides numerous alluvial gold occurrences in rivers and streams in the area there are also many remains of early mining. Similar to Kachagiani/Sakdrisi ore pits and galleries targeted superficially located, so-called oxidised, supergene high-grade ore zones (Hauptmann et al. 2010; Stöllner et al. 2010). Weathering of the original sulfidic carrier minerals releases micronuggets that are concentrated in streams due to their high density. They could be extracted with simple methods,

melted together and mechanically processed (Wolf et al. 2013, 39). With every new geotechnical innovation ore pits and mine galleries were most likely used again and again during different mining epochs (prehistoric, antique, Middle Ages, modern), i.e. existing mine galleries and ore pits were enlarged, waste dumps were cleared and claims were laterally extended. As a result, traces of earlier mining activities were either completely destroyed or, rarely, conserved in the cover filling. The gold-bearing dike rocks, exposed by erosion of the host rocks, often with waste dumps upstream, testify to the fact that the extraction of primary gold was not absolutely necessary in this region and that the metal was relatively easily obtained (Wolf/Kunze 2014, 128).

With this we can observe a socioeconomic transformation into a complex society during the middle of the 4th mill. BCE in the southern Caucasus. The abundance of metal deposits[16] (copper, gold, antimony, arsenic) and other raw materials (e.g. obsidian) can likely be seen as a basic criterion for the relationship between the southern Caucasus and the Near East (cf. Kunze et al. 2011, 20, 35–38; 2013, 80), which was established during the end of the 4th mill. BCE, as testified by multiple finds which clearly indicate a relationship with the Near East.[17]

Early Metallurgy in South-East Europe

The first evidence of the exploitation of copper as a new raw material in South-East Europe dates back to the early Neolithic, where the production was limited to smaller tools and jewellery pieces made largely out of pure copper or secondary copper ore (Neukirchen 2016, 28). Among these are a massive copper awl and a fishhook from the Romanian sites of Balomir and Gornea (Muhly 1988, 8; Borić 2009, 191). By the end of the 6th mill. BCE, interest in copper grew as evidenced by the appearance of more and more copper objects (Todorova/Vajsov 2001, 12), particularly from the Vinča Culture in Serbia (Šlijvar et al. 2006; Radivojević et al. 2010), the Boian Culture of the lower Danube (Vulpe 1970) and Karanovo V in Thrace (Todorova 1981). At Belovode in eastern Serbia, for example, a chain of production is partially recognisable, with evidence of the raw material and finished products (Usoe II, north-western Bulgaria) or waste products of the smelting process (copper slag) and the resulting tools (axes, chisels, armbands) (Todorova 1981, 4; Radivojević et al. 2010, 2779). A particularly concrete example from the Vinča site of Belovode represents the first pyrotechnological production of copper that became increasingly more intensive with the beginning of the Early Copper Age (beginning of the 5th mill. BCE). The settlement, which is located on a plateau about 140km south-east of Belgrade in Serbia and has been excavated since 1994, developed into a production and processing centre for copper (Borić 2009, 207 f.; Radivojević et al. 2010, 2778).[18] The social aspect of this new material is demonstrated through numerous grave goods, including beads, bracelets and pins found in the burial grounds of Gomolava (Borić 2009, 223), Kamnik, Slatino and Sesklo (Todorova 1999, 237, 241 fig. 4) as well as in early graves of the Durankulak necropolis in the Dobruja region (Todorova/Vajsov 2001, 8). Evidence of jewellery, however, is not the only indication of the social transformations. The rise in population at the end of the Neolithic resulted in an urgent need to increase productivity, which is characterised by the manufacturing and

16 The southern Caucasus is rich in abundantly occurring metals as well as in obsidian deposits. The aim of this article is not to discuss each deposit individually; this is done in the following publications: metal deposits e.g. Chernych 1992; Dshaparidze 2001; Twaltschrelidze 2001; Köster 2008; Obsidian occurrences e.g. Blackman et al. 1998; Badalyan et al. 2004; Chataigner/Gratuze 2014a; 2014b.

17 The controversial and much-discussed silver vessels from the Large Kurgan from Maykop in the northern Caucasus (end of the 4th mill. BCE) as well as the middle Bronze Age burial mounds from Karashamb (Armenia) and Trialeti (Georgia) are of particular relevance here, which, according to the current state of research indicate increased interaction with Iranian/Mesopotamian/Anatolian areas (recently Smith 2015, 99–102; Ivanova 2012 [Maikop]; Boehmer/Kossack 2000 [Karashamb/Trialeti]; Zischow 2004).

18 D. Borić proposes a settlement period from the middle of the second half of the 6th mill. BCE until the middle of the 5th mill. (Borić 2009, 212). Radivojević and her colleagues believe metallurgy to have been present already in initial phases at the beginning of the settlement period and pyrotechnology to have been introduced later, around 5,000 BCE onwards (Radivojević et al. 2010, 2778).

use of heavy metal tools and weapons (axes, hammer axes, chisels) (Todorova 1981, 4 f.; Todorova/Vajsov 2001, 28) and their impressive development in find contexts from Pločnik in Serbia (Borić 2009, 209–211).

From the beginning of the middle to the late Copper Age and the establishment of the Kodžadermen-Gumelniţa-Karanovo (KGK) VI cultural complex, a shift in settlements as well as metallurgical centres towards the Black Sea coast can be observed, the cause of which was probably due to further and more distinctive trade relationships with cultures along the Black Sea and the Danube as well as Central Europe (Todorova 1995, 87; Todorova/Vajsov 2001, 28), but maybe this is not the result of the copper trade alone. This change in the location of metallurgical centres is no doubt reflected in the 294 graves of Varna,[19] where, in 1972, a cemetery was accidentally unearthed during the excavation of a cable trench (Ivanov/Avramova 2000; Lichter 2001, 98–108; Todorova/Vajsov 2001, 1 f.).

The prehistoric metallurgy of the area under study has long been a focus of research due to its significance for the entire European cultural development. An independent development of South-East European copper metallurgy in comparison to that of the Near East and Greece had already been suggested by C. Renfrew in the 1960s (Renfrew 1969). It was, at that point, already known that the copper objects consisted of extremely pure copper (Junghans et al. 1968) and, for a long time, it was unclear whether it was extracted from pure, naturally occurring metallic copper or from copper ore extracted by smelting. Proper research into prehistoric metallurgy in Bulgaria began in the 1970s and 1980s. Gold reappeared as the main research focus with the discovery of the rich and wealthy furnished graves of Varna. The chronological development of copper tools, weapons and jewellery was subsequently more precisely determined – above all for stratified finds from the settlement mounds of Bulgaria, Romania and Serbia. In 1978, Evgenij N. Chernykh's monograph on prehistoric mining and metalworking in Bulgaria was published, including extensive series of analyses of the trace elements in the artefacts and the then-known copper deposits (Chernykh 1978). The two earliest copper mining sites were discovered at Rudna Glava in eastern Serbia (Jovanović 1982) and Ai Bunar in Thrace (Chernykh 1978, 56–78). The analysis of trace elements in the copper artefacts indicated early on the probable use of other deposits which were, at the time, largely unknown. The possible locations of mining areas for copper were further narrowed down using lead isotope analysis and dating of the ore deposits (Pernicka et al. 1997). These locations were spread out among the entire ore deposit zone stretching along the Sredna Gora and Rhodope mountain ranges and from the topographical view from eastern Serbia up until the Black Sea coast of southern Bulgaria. Since trace element patterns and lead isotope analysis show that not a single metal object derives from Rudna Glava, the major ore deposit of Majdanpek likely provided the source of the very pure copper (Pernicka et al. 1997). Other ore deposits in the southern Carpathian basin have been localised but have not been geochemically characterised like those of the eastern Serbian and Bulgarian deposits (Boroffka 2009).

Other deposits to the east and south of the harbour of Burgas in the back country of the southern Bulgarian Black Sea coast have also been localised by Chernykh. Among these are Varli Bryag and Černi Vrăh (Kara-bair) in the flatlands of the hilly county west of Burgas as well as ore deposits of Metoha, Rosen, Djado Toma, Korucheshme, Meden Rid (Bakarlăk), Propadnala Voda (Červeno Zname), Surneshko Kladenche and Čiplaka (Chernykh 1978, 19–25), all of which are referred to in academic literature as the Rosen Ore Field[20] (Bogdanov 1987, 252–291; Popov et al. 1993, 39–50), which is essentially the ridge of Medni Rid, extending south of Burgas between the Čukalija peninsula and the mouth of the river Ropotamo. A group directed by E. Pernicka succeeded in

19 According to recent research, the occupancy of the Varna necropolis dates roughly between 5,600 and 5,300 BCE into the first half/middle of the 5th mill. BCE (Higham et al. 2007; Krauss et al. 2016).

20 The term 'Rosen' has often led to confusion in recent literature, as is not clear in every case whether it refers to a toponym for the entire region with ore deposits or a specific mineralisation near the present-day town of Atia. Cf. Discussion of the field survey in this volume, 307–326.

showing that these deposits had already been used for the production of artefacts during the Copper Age, much more so than that of Ai Bunar (Pernicka et al. 1997). The geographical and geological descriptions of the ore deposits west and south of Burgas have been fairly inaccurate, for instance referred to in Chernykh (1978, 19–25) as the 'ore district of Strandža', in Pernicka et al. (1997) in the context of 'Sredna Gora' or in Dimitrov (2002) quite generally as the 'southeast Bulgarian' region. The ridges of Medni Rid are clearly offset from the geographical zone of Strandža by the valley of Djavolska reka. The basal complex was formed from the remains of a caldera of an old volcano, whose central area was the Sozopol peninsula. This formation was bordered to the north by the bay of Burgas and to the south by the bay of Primorsko and stretches about 35km inland from the present-day Black Sea coast.

From personal communication with E. Chernykh we have learned that, at the time of his site survey, there were no indications of early usage of the deposits during the Chalcolithic or Bronze Age. He does not, however, categorically rule this out and refers to a possible overprinting through later mining activity during antiquity. We are then dealing with an area which, before the surveys conducted by P. Leshtakov at the end of the 2000s, was treated widely in archaeology as a terra incognita of prehistoric times (Parzinger 1993, 84).

Prehistoric gold metallurgy abruptly became of tremendous importance along with the discovery of the burial fields from Varna I in the year 1972. It is still an unparalleled phenomenon within its chronological and cultural context and beyond. Significantly, the abundant and elaborate products of fine metalworking most articulately express the achievements connected with the inception of gold metallurgy. However, considering the obviously high expertise it seems as if these objects had already surpassed the inventive stage of fine metalworking. Thus, the question arises, when, where and why gold metallurgy was actually invented. In this respect, the Varna I cemetery represents an unusual manifestation. Since its discovery in 1972, the site has often been discussed as representing a completely new and yet unparalleled organisation of the Chalcolithic society (see for example Renfrew 1978; Marazov 1988; Lichardus 1991; Chapman et al. 2006; Hansen 2013). The unequal distribution of the grave goods, especially of the gold objects, was frequently interpreted as indication for a hierarchically structured community (Renfrew 1986). So far, there is nowhere else a comparable abundance of Chalcolithic gold objects. In total approximately 3,100 items were recorded, belonging to the assemblages of 65 out of the 320 burials that have been excavated. Amongst these 65 burials, five burials alone comprise over 80% of the whole gold assemblage.

According to earlier research casting was formerly rarely considered to have played a major role in the production of the gold objects from Varna. Instead, simple cold-working methods, i.e. cold-welding of gold nuggets or their deformation by hammering, were assumed to be the basic methods for the supposed earliest gold of mankind (Eluère 1989; Guerra/Calligaro 2003; Raub 1995; Renfrew 1978). However, according to examination of the production techniques of the Varna objects by Echt et al. (1991) and recent comprehensive studies within a project funded by the German Research Foundation (Deutsche Forschungsgemeinschaft; PE 405/25-1) casting could be shown to have been a regular method for the production of the gold artefacts (Dimitrov 2013; Leusch et al. 2015). Even lost-wax casting apparently was applied for producing solid as well as hollow objects of thin-walled section.

Furthermore, it was found that gold was also alloyed with copper at concentrations of more than 30%. These exceed by far the copper contents in natural gold and were possibly intended to alter the colour of the silver-rich gold. Hence, these objects attest to the mixing of both metals and, more importantly, represent the earliest intentional alloys so far recorded. Regardless of their intention, these alloys (even if they only represent a small part of the gold objects so far discovered from Varna) indicate a technological link between copper and gold metallurgy.

The origin of the gold was also a major research issue. First analyses by A. Hartmann (1978) were interpreted to show that the Chalcolithic gold of Bulgaria and Romania was possibly extracted from mines in the southern Caucasus and exported over long distances. Within the project above mentioned new analytical techniques, like

laser ablation coupled with ICP mass spectrometry, were applied and showed that Hartmann's suggestion of provenance is rather unlikely. In the above mentioned project it was possible to analyse all gold finds from the Varna I cemetery and further gold objects from contemporary settlements. Furthermore, a geological field survey revealed that native gold and also platinum metals occur in the regional stream network that drains the Strandža mountains, the Sredna Gora and the Balkan main ridge towards the Black Sea. Since the presence of platinum in the gold objects from Varna was the main reason that Hartmann suggested the southern Caucasus as source region, this is no more compelling. It is more likely that the gold of the Varna I cemetery derives from regional sources.

In this volume, the results of the investigations into prehistoric copper mining in the mining district of Medni Rid will be presented along with the research of its surrounding Late Neolithic/Copper Age settlements.

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I. Archaeology of the Coastal Area in Southeast Bulgaria

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The Prehistoric Site Akladi Cheiri, Chernomorets

Keywords: prehistoric settlement, prehistoric burials, early metallurgy, Late Neolithic, Chalcolithic, Transitional Period, Early Bronze Age, anthropomorphic figurines

In 2008 a previously unknown prehistoric site was discovered in the north-western area of Sozopol Bay during the construction of a holiday village at the Akladi Cheiri locality, 2.35km south-east of Chernomorets town (*fig. 1*). It is located about 250m west of the contemporary seashore lying on a terrace slightly sloping east/west, 1 to 4m above sea level. According to previously known data, the site area exceeds 1ha. Its eastern periphery is covered by a thick layer of sand which does not allow its true size to be defined.

In the course of the period of October 2008 to April 2009 two sectors around the already finished buildings of the holiday village with a total area of 0.18ha were fully explored. The study of the western sector began in 2008. It covers the outer space around the curve of the building, designed to be a car park. The eastern sector is in the western half of the inner courtyard intended for the construction of a swimming pool (*fig. 2*). It has been determined that the site is multi-layered and contains layers and structures from the Late Neolithic, the Early and Late Copper Age, and the Early Bronze Age. Three graves from the first half of the 4th mill. BC have also been documented.

The Late Neolithic Level and Features (5400–4900 BC)

The earliest artefacts from the site relate to the Late Neolithic and are contemporaneous with the Karanovo III/IV period in Thrace. The cultural layer of this period is 0.30 to 0.40m thick. More than forty pits were registered within it; they are of a significant size and in most cases more than 1m deep. The pits are of an elliptical or irregular shape. A group of pits is distinguished, filled with ash, charcoal, burnt destruction debris, and soil. Their fillings contain a large number of whole and fragmented pottery, tools of stone, flint and bone, ceramic anthropomorphic figurines, adornments and animal bones. In the eastern sector a large area of irregular shape (over 80m^2 in size) was explored. Its upper surface was covered with a layer of ash 2 to 5cm thick. The excavated area represents a complicated system of many smaller pits reaching a depth of 1.20 to 1.30m. Its filling contained a large number of archaeological artefacts similar to that in the other excavated areas. The repeatability of a number of elements in the filling of the pits, the absence of postholes and other data suggest the ritual nature of these structures.

Pit 1 (Late Neolithic, Karanovo IV)

The pit is located in the north-western corner of sq. K8. It is oval in shape, with dimensions in the east-west direction of 1.80m. Its northern periphery was destroyed during the construction of a modern building. The walls of the pit gradually narrow in depth. The bottom is flat, reached at 0.70m from the level of detection (1.20m from the main reference point [mR]). Three levels of filling have been distinguished from the bottom up as follows: the layer immediately above the bottom of the pit is dark, brown, loose, and of a low density. A high concentration of animal bones was registered within it. Next comes a 20cm thick



Fig. 1. Akladi Cheiri. Aerial photograph of the site from the north during the building activities and following rescue excavations.

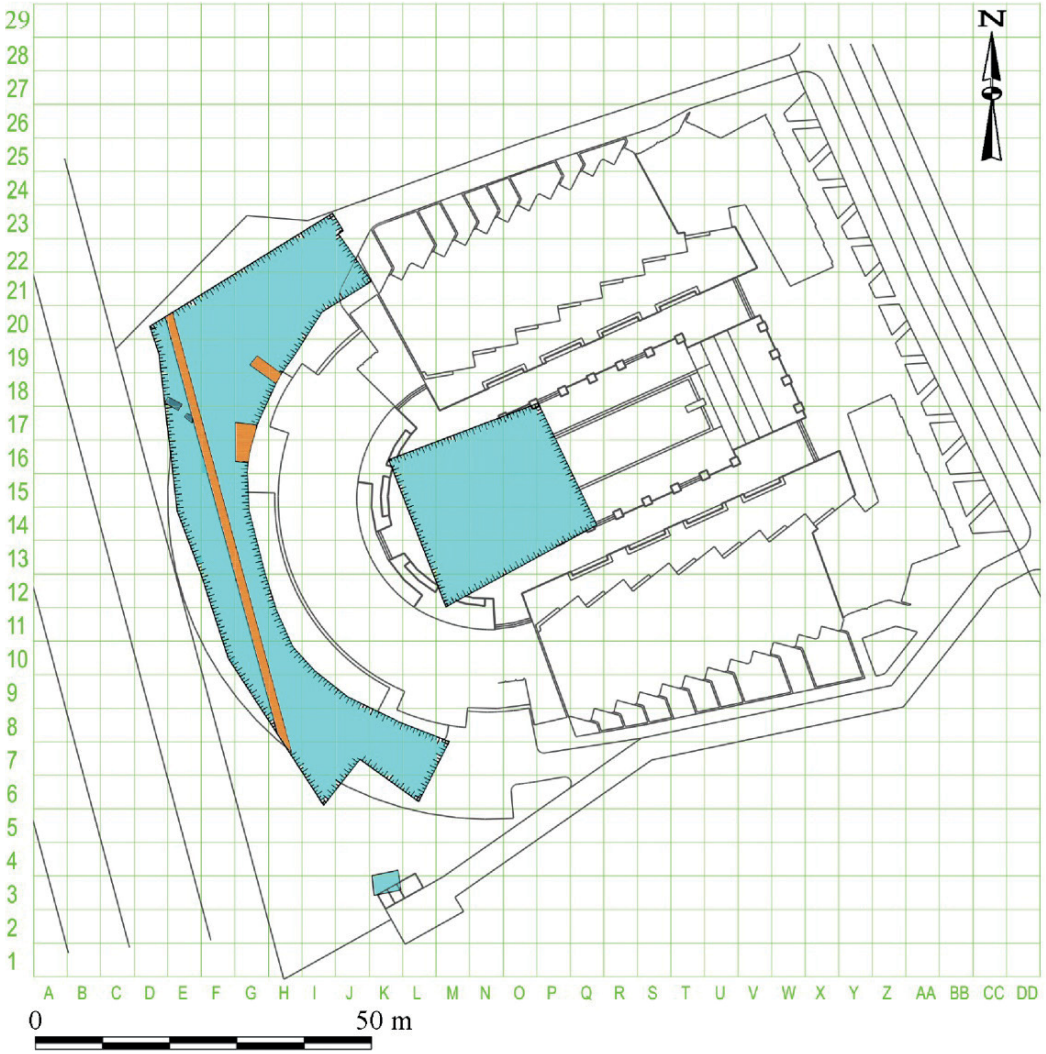

Fig. 2. Akladi Cheiri. Plan of the building with positions of excavation trenches (turquoise) in the courtyard and immediately west of the complex.

layer of high-density beige, sandy soil. The upper 20 to 25cm from the level of detection represent brown-ochre clay soil with a loose, homogeneous structure.

The filling of the pit contains a high concentration of Late Neolithic artefacts contemporaneous with the Karanovo IV period. Alongside pottery fragments, animal bones were also registered, as well as ten to fifteen rough stones with medium and small dimensions, pieces of scorched clay and some fragments of daub from a fireplace/oven. The small objects are represented by some flint artefacts and stone tools (whole and fragmented).

Pit 6 (Late Neolithic, Karanovo IV)

The pit is located in the north-western sector of sq. I9 and the south-eastern sector of I10. Its north-eastern half was destroyed during the construction of a modern building.

The profile of the trench for the building clearly shows filling levels. It is round in shape and 1.35m in diameter (in the north-west/south-east direction). The walls are well shaped and expanding in depth. The bottom is flat and was reached at a depth of 0.55m from the level of detection (0.92m from mR). The bottom is 1.40m in diameter.

Three levels of filling were distinguished. From the bottom up they are as follows:

The layer just above the bottom of the pit is light brown, with a clay structure and inclusions of small pieces of charcoal and daub in a lower concentration compared to the upper layer. Large fragments of pottery have been registered as well as animal bones, a stone pounder and a fragment of a quern.

Then a layer of grey-brown clay soil with inclusions of small pieces of daub and charcoal followed. It was 10 to 15cm thick and contained pottery fragments in a low concentration as well as single large animal bones.

The filling of the pit in the upper 15 to 20cm from the level of detection (depth of 0.52cm from mR) was composed of burnt destruction debris of incompact structure mixed with fragments of daub from a fireplace/oven measuring up to 7mm. No other archaeological artefacts within this level of filling were registered.

Pit 7 (Karanovo III/IV)

The pit/granary is located in the south-eastern sector of sq. I7. It is round in shape, 0.75m in diameter. The bottom is flat, 0.55m in diameter, plastered with a layer of clay, reached at a depth of 0.60m from the level of detection (1.41m from mR). The longitudinal section is of a truncated cone shape.

The filling is a light brown, loose clay soil with inclusions of charcoal and small pieces of daub. The walls are plastered with a layer of beige-ochre clay up to 3 to 4cm thick. Three successive coatings of similar clay up to 3cm thick were registered at different levels within the filling.

The artefacts within the filling of the pit are pottery fragments, several animal bones and mussel shells, and a ceramic zoomorphic piece. Several small and medium-size unprocessed stones were also registered near the bottom of the pit.

Pit 8 (Karanovo III/IV)

The pit/granary is located in the north-eastern sector of sq. I6. It is similar in shape and size to pits 3 and 7. Its shape is round, 0.75m in diameter. The walls are plastered with a layer of beige-ochre clay up to 3cm thick. In the upper half the walls are funnel-shaped, and in depth they begin to gradually expand and become rounded towards the bottom. The bottom is flat, also coated, reached at a depth of 0.55m from the level of detection (1.47m from mR). It is 0.65m in diameter. Two levels of filling were distinguished. The layer next to the bottom is composed of light grey clay soil with inclusions of ash. The pottery registered at this level is rather fragmented, while the animal bones are large and well preserved. Single pieces of malachite ore are also present as well as a bone tool and a ceramic disk. The layer at a depth of 0.30m from the detection level is composed of yellowish-brown homogeneous loose soil mixed with charcoal. It contains pottery fragments and animal bones in a medium concentration and many mussels. The filling of the pit at the level of detection is of yellowish-brown clay soil. Its thickness is about 3cm and probably served to seal up the pit.

Pit 12 (Karanovo III/IV)

The pit is located in the southern sector of sq. H9 and the northern sector of G10. It is round in shape, 1.05m in diameter. Its walls are upright, slightly narrowing in depth. The bottom is flat, reached at a depth of 0.35m from the level of detection (1.10m from mR). Its diameter is 0.85m. The longitudinal section of the pit has an inverted truncated cone shape. Its eastern part encroaches on pit 13.

The filling is homogeneous, composed of ochre-brown clay soil of medium density mixed with small pieces of daub and charcoal. Pottery fragments occur in a low concentration. Single animal bones were also found, and a flint artefact.

Pit 14 (Karanovo III/IV)

The pit is located in the north-eastern sector of sq. K12 and the southwestern sector of G12. Its eastern half was destroyed by a trench for an optical cable. The diameter of the surviving western half of the pit is 1.45m (width east/west 0.80m). The walls are almost vertical and the bottom flat, reached at a depth of 0.30m from the level of detection (0.62m from mR). Vertically the pit has a cylindrical shape. Its filling is composed of homogeneous brown loose slightly greyish soil with inclusions of charcoal, small crushed pieces of daub and beige ash spots.

Pottery fragments occur in a medium to high concentration. Animal bones were also found, mainly large and well preserved, as well as a flint artefact.

Pit 15 (Neolithic)

The pit was registered at the borderline between sq. I7 and H7. It is round in shape, 1.20m in diameter. Its walls are vertical. Because of the high level of groundwater, the bottom of the pit could not be reached.

The filling is composed of yellowish clay soil of high density. The concentration of pottery fragments is very low, just five to six small pieces.

Pit 16 (Karanovo III/IV)

The pit is located in the south-western sector of sq. F12. Its shape is round, 1.40m in diameter. The walls are plastered with whitish clay, 8 to 10mm thick. The shape is oval measuring 1.60m east/west and 1.30m north/south. Due to abundant groundwater, the bottom of the pit could not be reached.

Some levels of filling were distinguished. From the bottom up they are as follows:

At 1.10m from the level of detection the filling is composed of brown clay loose soil with a high concentration of small pieces of charcoal.

At a depth of 0.90m from the level of detection, a level consisting of burnt thick clay red in colour and a high concentration of charcoal was revealed. It is about 10 to 15cm thick.

The next level of the filling of the pit is composed of whitish-yellow coating mixed with gravel, small pieces of daub and charcoal. The coating is very hard and compact. The thickness of this level is about 20cm. The concentration of pottery fragments is lower than the that within the previous level. No animal bones were registered. Three flint artefacts were found. The uppermost layer contains brown clay loose soil with a high concentration of small pieces of charcoal. The concentration of pottery fragments is high as the fragments are mostly small. Many animal bones and flint artefacts were registered. A bone object was also found.

Pit 17 (Karanovo III/IV)

The pit is located in the south-eastern sector of sq. I9 and the south-western sector of J8. It is of irregularly elliptical shape, measuring 1.20m east/west and 2.30m north/south. Its eastern and north-eastern parts had been destroyed by a trench for the foundations of a modern building. The filling is composed of grey-black soil of a low density mixed with many small pieces of charcoal. Whitish clay spots and traces of burnt clay were registered at times. The concentration of pottery fragments is high as most of them are small to medium in size. Animal bones were found as well as flint artefacts and a stone adze.

Pit 18 (Neolithic)

The pit is located in the south-eastern sector of sq. I9. It is elliptical in shape, measuring 0.86m east/west and 1.06m north/south.

Its filling is homogeneous, composed of greyish clay soil with a medium high density. Pottery fragments and animal bones occur in low concentrations.



Fig. 3. Akladi Cheiri. Profile of Late Neolithic pit 20.

Pit 19 (Karanovo III/IV)

The pit is located in the northern half of sq. I9. Its walls are upright and the bottom is flat, reached at a depth of 0.60m from the level of detection.

The filling is composed of homogeneous grey-brownish loose soil. A pile of seven stones was registered on the bottom, six of them small in size, from 8 to 14cm, while the seventh is larger at 0.20cm long and 0.18cm wide. Five of the stones are concentrated in the middle of the pit, and the other two are in the periphery next to the southern and south-eastern wall respectively.

The concentration of pottery fragments is low. Three small animal bones were found, as well as a piece of copper ore and a flint artefact.

Pit 20 (Karanovo III/IV)

The pit is located in the south-western sector of sq. F12 and the north-eastern sector of F11. Its western periphery falls into the western profile of the site and remains unexcavated, and its south-western periphery was partially destroyed by a modern trench for a pipe. The pit is elliptical in shape, measuring (in its excavated part) 2.10m east/west and 2.60m north/south (*fig. 3*).

The exploration of the pit is complicated by groundwater, rising up to 0.60m from the level of detection.

Some levels of filling were distinguished:

At a depth of 0.80m from the level of detection in the southern half of the pit a strip of burnt clay about 0.10m thick was reached.

Above this, from 0.60 to 0.80m, the next level is composed of whitish clay soil (ash) with a high concentration of charcoal in the southern half of the pit. The thickness of the level varies from 0.20m in the northern half to 0.40m in the southern one. The concentration of pottery fragments is high. Flint artefacts were found, as well as a bone tool and a head of a ceramic figurine.

At a depth of 0.50m from the level of detection a level of whitish clay was reached. It consists of a very hard texture mixed with ash, burnt clay, which was red in colour, and a concentration of charcoal.

From the surface to 0.50m from the detection level, the filling is grey-whitish in colour, loose and of a low density, with a concentration of small pieces of charcoal and daub. The concentration of pottery fragments and animal bones is high.

Pit 21 (Karanovo III/IV)

The pit is located in the south-western sector of sq. G10. It is oval in shape, measuring 1.90m east/west and 1.60m north/south. Its walls are upright and narrow slightly at a depth of 0.60m from the level of detection. The bottom is flat, reached at a depth of 1.20m from detection level.

The filling is composed of grey-whitish clay soil mixed with ash spots with a high concentration of small pieces of charcoal and four large pieces of burnt debris that are reddish in colour. The concentration of pottery fragments and animal bones is high. Some flint artefacts and two bone tools were also found.

The lower part of a pot with a deliberately made hole in the middle of its base was found at the bottom.



Fig. 4. Akladi Cheiri. Profile of Late Neolithic pit 30.

Pit 22 (Karanovo III/IV)

The pit is located in the southern sector of sq. F14. It is round in shape and 0.60m in diameter. The walls are coated with whitish fine clay 2 to 4cm thick. In depth, the walls of the pit expand, gradually becoming pear-shaped. The bottom is flat, reached at a depth of 0.65 to 0.70m from the level of detection.

The filling is composed of brownish loose soil mixed with tiny pieces of charcoal and mussels. Small pieces of daub and burnt spots were registered at the time.

The concentration of pottery fragments is low. Some animal bones, two small unprocessed stones and mussel shells with no traces of holes were also found.

Pit 25 (Karanovo III/IV)

The pit is located in the northern half of sq. F17 and the eastern half of G17. It is elliptical in shape, measuring 3.60m east/west and 2.40m north/south.

The filling is composed of grey-brown loose soil of low density, occasionally mixed with small fragments of charcoal and very small pieces of daub. The concentrations of pottery fragments and animal bones are high. Some flint artefacts, a biconical ceramic object (symbolic representation of a grain or slingshot), a stone wedge and two fragments of stone tools were also found in the pit.

Pit 26 (Neolithic?)

The pit is located in the southern half of sq. F16. It is round in shape and 1.36m in diameter. In depth, it gradually enlarges and acquires a reversed conical shape. The bottom is flat, at a depth of 0.80m from the level of detection. The filling is composed of dark grey to black sandy soil of a low density. The concentration of pottery fragments is low.

Pit 30 (Karanovo III/IV)

The pit is located in the north-western half of sq. E16, partially destroyed by pit 29. It is elliptical in shape, measuring 1.60m north/south and 1.40m east/west (*fig. 4*). Due to constant groundwater it was not possible to reach the bottom.

The filling is composed of grey clay soil of a low density saturated with tiny pieces of charcoal. The pit is full of burnt destruction debris, varying in size. Pottery fragments and animal bones occur in high concentration. The depth reached is 1.50m from the level of detection.

Pit 31 (Karanovo III/IV)

The pit is located in sq. F15. It is of a regular oval shape, measuring 1.20m east/west and 1.30m north/south. Its walls are upright and the bottom is flat, reached at a depth of 0.20m from the level of detection.

The filling is grey and loose. The presence of pieces of daub and small fragments of charcoal was registered on the bottom of the pit, in its western half, 0.20m in depth. The concentration of pottery fragments and animal bones is low.

Pit 32 (Karanovo III/IV)

The pit is located in the eastern sector of sq. G19. Its southern part has been destroyed by a modern trench for the foundations of a building.

The filling is composed of yellowish-brown clay soil. Small pieces of charcoal and daub were registered. Fragments of a clay-made structure were revealed as well as burnt destruction debris

with imprints of sticks on them. Pottery fragments occur in a medium high concentration.

Pit 33 (Karanovo III/IV)

The pit is located in the central sector of sq. H19. Its shape is elliptical. The walls are vertical and the bottom is flat, reached at a depth of 1.00m from the level of detection.

The filling is dark brown along the periphery and yellowish-brown in the central part. A concentration of small pieces of burnt destruction debris and charcoal was registered from the surface to the bottom of the pit. Several single layers of very dusty beige soil were distinguished, concentrated in the north-western half of the pit. At a depth of 0.35 to 0.40 and 0.60m, compact whitish spots and yellowish-brown loose soil were revealed. Pottery fragments and animal bones occur in a high concentration up to 0.40m in depth, decreasing downwards. Bones of large animals, horns of goat and deer, and antlers (?) prevail. The bones are mostly in the north-western part of the pit where the whitish spots were registered. Some flint artefacts, bone tools (more than ten), a semi-manufactured stone chisel, a stone adze and three stone pounders were also found in this pit.

Pit 35 (Karanovo III/IV)

The pit is located in the north-eastern sector of sq. F15 and the south-eastern sector of sq. F16. It is of irregularly elliptical shape, measuring 3.20m east/west and 3.35m north/south (*fig. 5*). At a depth of 0.70m from the level of detection the pit narrows to form a step-like curve, acquiring a conical shape. At this level it measures 2.10m north/south. The bottom is flat, reached at a depth of 1.40m from the detection level. The south-eastern and north-eastern borders of the pit have been destroyed by some other disturbance.

Several levels of filling were distinguished. From the bottom up they are as follows:

From the bottom of the pit up to 0.80m the filling is composed of whitish clay soil (ash) mixed with small pieces of charcoal and daub.



Fig. 5. Akladi Cheiri. Profile of Late Neolithic pit 35.

At a depth of 0.80m in the northern and 0.90m in the eastern part of the pit a black burnt layer was revealed, 16cm thick. It runs arc-wise through the entire pit. The concentration of pottery fragments is high.

A layer of yellowish-white sandy-clay mixed with ash, charcoal and daub follows. It is 15 to 20cm thick. The concentration of pottery fragments continues to be high. The next level of the filling also contains whitish ash but mixed with grey-yellowish loose soil. At certain places there the presence of small pieces of charcoal and daub, burnt clay and a white sandy substance was registered. Its thickness is about 20 to 30cm. Within this layer three fragments of a clay structure were found, probably coming from grain storage, as well as some flint artefacts, a bone tool, several pounders, and two pieces of malachite. The concentration of pottery fragments is still high. From the surface down to 0.20m the filling is composed of whitish loose clay soil containing a high concentration of ash. The concentration of pottery fragments is also high. Animal bones, a piece of copper ore, a ceramic spindle whorl, two or three fragments of stone tools and several pieces of daub from an oven were found there.

Pit 36 (Karanovo III/IV)

The pit is located in sq. E18. It is elliptical in shape, measuring 1.50m east/west and 1.80m north/south. The bottom is flat, reached at a depth of 0.65 to 0.70m from the detection level.

The filling of the pit is very similar to those in pits 32, 33, and 35. Several layers of filling were distinguished. From the bottom up they are as follows:

From the bottom up to 0.50m from the detection level the filling is composed of grey-black loose clay soil mixed with small pieces of charcoal. At a depth of 0.50m from the detection level, in the western half of the pit, a pile, consisting of a large unprocessed stone and three animal horns, was registered

The next level is composed of white-yellowish loose ash saturated with charcoal, covering the entire area of the pit, with a thickness of more than 10cm. The concentration of pottery fragments is still high, among them was also a large number of animal bones from a large animal with horns. The filling contains several fragments of querns.

From the level of detection down to 0.20m the filling is composed of grey-black loose clay soil mixed with small pieces of charcoal. The concentration of pottery fragments is high. A fragment of a ceramic anthropomorphic figurine was also found there.

Pit 37 (Karanovo III/IV)

The pit is located in the eastern sector of sq. G20 and the western half of sq. H20. Its shape is approximately oval, measuring 2.28m east/west and 2.20m north/south. At a depth of 1.20m from the level of detection the pit narrows and its measurements become 1.60m east/west and 1.60m north/south. The bottom is flat, reached at a depth of 1.70 to 1.75m from the detection level (1.83m from mR).

From the bottom up to 0.25m the filling is dark grey and of a loose structure, at times mixed with small pieces of charcoal and daub. The pottery fragments and animal bones occur in a medium high concentration. A high concentration of flint artefacts (mostly small in size) was registered. A fragment of a ceramic anthropomorphic figurine and a piece of copper ore come from the same level. At a depth of 1.30m in the western part of the pit a mill-stone was revealed, lying with its smooth side up. Its dimensions are: 0.45m in length and 0.25m in width. At a depth of 0.85m in the northern half of the pit a further mill-stone was found, measuring 0.50m in length, 0.25m in width and 0.12m in thickness. It was lying on one of its long sides next to the northern wall of the pit, its smooth side facing the interior of the pit. The concentration of pottery fragments and animal bones is high. The filling of the pit from the detection level down to 0.25cm is composed of yellowish-brown soil with a high density.

Pit 39 (Neolithic)

The pit/granary is located in the central part of sq. F12. It is elliptical in shape, measuring 0.90m east/west and 0.80m north/south.

The walls are plastered with whitish-yellow clay, 3cm thick. The filling is composed of brownish-yellow loose soil occasionally mixed with small pieces of charcoal.

Pit 40 (Neolithic)

The pit was registered in the central part of sq. G19. It is almost round in shape, measuring 0.83m north/south and 0.86m east/west. The bottom is reached at a depth of 0.38m from the *repère*.

The filling is composed of yellowish-brown clay soil of a medium high density. The pottery fragments occur in a very low concentration.

Pit 43 (Late Neolithic)

The pit is located in sq. G21. It is oval in shape, measuring 0.65m east/west and 0.70m north/south. The filling is composed of yellowish-brown sandy loose soil, occasionally mixed with pieces of charcoal and daub. The bottom is reached at a depth of 0.70m from the level of detection. Pottery fragments occur in a low concentration.

Pit 44 (Late Neolithic)

The pit is located in sq. G15. The filling is composed of whitish loose soil of a low density. A pile of burnt destruction debris was registered in the middle part of the pit. The concentration of pottery fragments is very high. Some flint artefacts,

a piece of copper ore and a bone tool were also discovered.

Pit 45 (Late Neolithic)

The pit is located in the north-western corner of sq. J21, the south-western corner of sq. I21, the south-eastern corner of I22 and the north-western corner of J22. It is oval in shape, measuring 1.72m east/west and 1.85m north/south. The bottom is flat, reached at a depth of 0.40m from the level of detection.

The filling is composed of dark grey clay soil of a high density mixed with small pieces of daub. Pottery fragments and animal bones occur in a medium high concentration. Some pieces of copper ore were discovered in the pit.

Pit 46 (Karanovo III/IV)

The pit is located in the north-western sector of sq. G14 and the south-eastern sector of G13. It is oval in shape, measuring 1.70m east/west and 0.80m north/south.

The filling is composed of grey-brown sandy loose soil, occasionally with whitish spots of ash mixed with small pieces of daub. At a depth of 0.20m from the level of detection a level of yellowish-brown sandy soil was reached, at times mixed with a concentration of charcoal. Pottery fragments occur in a high concentration.

Pit 49 (Karanovo III/IV)

The pit is located in several squares, the north-eastern sector of sq. H21, the south-eastern sector of sq. H22, the south-western sector of sq. G21 and the north-western sector of sq. G22. It is oval in shape, measuring 2.10m east/west and 1.90m north/south. In depth, the pit narrows, acquiring an inverted conical shape. The bottom is flat, reached at a depth of 1.30m from the level of detection.

The filling is composed of grey-beige loose soil of a low density. At time spots of burnt clay 10 to 25cm thick were registered, as well as concentrations of small pieces of charcoal and daub.

Pit 49A (Karanovo III/IV)

The pit is located in the south-western part of sq. H22, next to the eastern periphery of pit 49. It is elliptical in shape, measuring 1.20m north-east/south-west and 2.85m south-east/north-west. The bottom is flat, reached at a depth of 0.60m from the level of detection.

The filling is a non-homogeneous light grey-brown in colour and of a medium high density, mixed with small pieces of charcoal, ash spots and a layer of burnt clay destruction debris. A whole pot (of closed shape) was revealed in situ, close to the northern walls of the pit, at the level of detection. In the central part of the pit, at a depth of 10 to 20cm from the detection level, a spot containing an increased concentration of a burnt organic (black layer) was registered. Several pieces of compact clay destruction debris from a fireplace/oven were found in the southern sector of the pit, fragments of disturbed surface coating, 4cm thick on average. Pottery fragments occur in a high concentration.

Pit 50A (Neolithic)

The pit is round in shape, 1.25m in diameter. Because of high groundwater, its bottom was not reached.

The filling is homogeneous, composed of grey-brown clay soil mixed with small pieces of charcoal. Down to a depth of 2.80m from the level of detection, the filling had the same characteristics. Pottery fragments and animal bones occur in a high concentration.

Down to 3.50m in depth the filling remains the same, but the concentration of charcoal increases and ash inclusions appear.

From 3.50m to 5.00m from the level of detection the layer is of grey-brown clay soil mixed with charcoal, ash inclusions, and broken daub. The pottery fragments registered at this level occur in a high concentration and are mostly large in size.

Among the animal bones recovered, massive bones belonging to large animals prevail; there are also many horns and fragments of skulls. A whole auroch skull (*Bos taurus primigenius*) was found at a depth of 4.00m. At the same depth an increased concentration of pieces of burnt clay destruction debris of a compact structure and large in size (up to 0.15 x 0.20m) was registered, as well as several fragments of surface coating from a fireplace/oven with an average thickness of 0.05m and a width of 0.10m. Many fragments of stone tools were found, as well as complete shapes and a bone awl. Pieces of well-preserved non-burnt wood, about twenty fragments of small and medium size (up to 0.10 x 0.18m), came from a depth of 4.80m.

At a depth of 5.10 to 5.40m the filling is composed of darker grey clay soil of a coarse structure and a high density, containing grey-ochre spots, charcoal, tiny quartz stones, and small pieces of burnt daub. Pottery fragments found within this layer occur in a medium high concentration, consisting of large pieces, mostly of thick-wall pots with a poorly preserved friable surface. Animal bones occur in a very high concentration, coming mainly from very large animals but also from quite small ones. Several large pieces of burnt daub from a compact structure were also registered. These were brick-red in colour, medium-coarse in texture mixed with prevailing inorganic inclusions and measuring up to 0.08 x 0.16m. Most of these have a face surface or imprints of poles about 1.5cm in diameter. The layer also contains several large crushed stones, two fragments of querns, a wooden artefact (probably a handle), a round object made from a seashell, displaying an attempt at piercing, a bone chisel and several fragments of and two whole stone pounders. At the same depth a large amount of well-preserved non-burnt wood was also found. Most of the fragments have a rectangular section or at least one side flat, so they might have belonged to beams or planks. The largest measure up to 0.50m. Probably the fragments were a part of a kind of wooden construction connected with the pit. Among the more shapeless pieces of wood there are also roots (?), as well as small twigs up to 1cm thick. Most of these have their bark preserved. One of the fragments displays traces of working with a tool (an axe). This is a round hewn beam with traces of cutting in several places.

The exploration of the pit was discontinued at a depth of 5.40m from the detection level, the filling not being fully removed.

Pit 55 (Neolithic?)

The pit is located in the northern sector of sq. N16. Its northern periphery falls into the area of sq. N17. It is round in shape and 1.30m in diameter. Its walls are vertical, slightly expanding in depth. The bottom is flat, 1.10m in diameter, reached at a depth of 0.60m from the level of detection. The filling is composed of dark brown homogeneous clay, and loose soil. A large fragment of a thick-walled pot was found close to the wall in the western sector of the pit, at a depth of 0.20m. By depth, the soil lightens becoming non-homogeneous and mixed with yellowish sterile spots. Pottery fragments occur in a low concentration.

Pit 56 (Neolithic?)

The pit is located at the border of sq. H22, I22–23. It is oval in shape, measuring 2.20m north/south and 2.10m east/west. The bottom was reached at a depth of 1.70m from the level of detection. The walls are heavily bevelled down to a depth of 0.70 to 0.90m from the detection level and then expanding smoothly to sag just above the bottom.

The layer next to the bottom and around the walls of the pit is brighter, light grey-brown, of a coarser texture and mixed with small stones. Pottery fragments and flint artefacts occur in a higher concentration compared to the upper levels (270 flint pieces from a depth of 1.20 to 1.70m from the detection level). The filling up to 0.80m is of a non-homogeneous nature, light gray to gray loamy soil with impurities of ash, charcoal and pieces of burned clay. At a depth of 1.25 to 1.30m from the detection level a layer of burnt clay destruction debris 0.15 to 0.20m thick was registered. Above it a layer of ash of 3 to 4cm in thickness appears.

At a depth of 0.80m from the detection level the layer acquires an ashy nature and grey colour, and the concentration of small pieces of charcoal and burnt clay destruction debris increases. From this level, the artefact concentration grows

sharply, consisting of pottery fragments, animal bones (among them bird and fish bones) and flint pieces (about seventy). The filling also contains several mussels.

The filling at the level of detection is composed of dark, light grey-brown soil of a loose structure and inclusions of small pieces of crushed daub. Occasional layers of ash and burnt clay destruction spots were registered. Pottery fragments occur in a high concentration. Animal bones, several flint artefacts, a fragment and a complete bone tool, and a fragment of a stone axe were found there.



Fig. 6. Akladi Cheiri. Profile of Late Neolithic pit 59.

Pit 57 (Neolithic?)

The pit is located in the south-eastern sector of sq. N17. It is oval in shape, measuring 1.50m north/south and 1.80m east/west. The walls are relatively regularly formed, slightly expanding in depth. The bottom is flat, reached at a depth of 0.45m from the detection level. The filling is homogeneous, composed of dark brown, comparatively loose soil mixed with small pieces of charcoal and daub in a high concentration. Pottery fragments and animal bones occur in a medium concentration. Four flint artefacts, several pieces of copper ore (malachite), including two large samples and two red ochre lumps were also found.

Pit 58 (Neolithic?)

The pit is located in the western sector of sq. O17. The filling is composed of dark grey clay soil of a low density mixed with small pieces of daub and crushed seashells. Some small pieces of copper ore (malachite) and several whole and many fragments of mussels were found.

Pit 59 (Karanovo III/IV)

The pit is located at the borderline between sq. H22–23 and I22–23. It is of an irregularly oval shape, measuring 1.70m north/south and 3.30m east/west (*fig. 6*). The northern half of the pit remains in the unexplored area. The bottom is flat, reached at a depth of 1.00m from the level of detection. The walls are unevenly shaped, strongly sloping in the south and southeast, and slightly expanding in depth in the western and southwestern parts of the pit.

The following layers were distinguished within the filling:

The layer next to the bottom is brighter, beige-brown, with yellowish-brown sterile spots, mixed with small pieces of daub and charcoal. At a depth of 0.90m from the detection level a more compact layer was registered containing burnt organic material. The filling at a depth of 0.50 to 0.90m from the detection level displays a layered nature of alternating ash up to 0.20m thick and burnt destruction debris up to 0.10 to 0.15m thick. At a depth of 0.30m a layer of a compact coarse nature appears, and below it, a further level of burnt destruction debris.

The filling at the level of detection is composed of homogeneous grey-brown loose soil mixed with small pieces of charcoal. Pottery fragments occur in a high concentration. The ashy layer contains a high concentration of pottery fragments. Three stone pounders, a fragment of a quern, a stone axe, a bone tool, a ceramic bowl (with 2/3 of the shape preserved), a fragment of a ceramic stopper and eight flint artefacts were discovered there.

Pit 60 (Karanovo III/IV)

The pit is located in the central northern part of sq. O14. The filling is homogeneous, loose and mixed with small pieces of daub and charcoal. At

a depth of 0.60m from the detection level a light brown grizzly clay layer, almost without impurities, was registered. Pottery fragments and animal bones occur in a high concentration. A ceramic spindle whorl, a half-preserved mussel shell and many flint artefacts were discovered.

Pit 62 (Karanovo III/IV)

The pit is located at the borderline between sq. M14-15 and N14-15. Its shape is that of an irregular circle, measuring 2.35m north/south and 2.20m east/west. The bottom is flat, reached at a depth of 0.60m from the level of detection. Its diameter is 1.85m. The walls are evenly shaped and slightly bevelled. The longitudinal section has a truncated conical shape. The filling is grey-brown, homogeneous and loose, mixed with small pieces of daub and charcoal. At a depth of 0.25m in the north and 0.50m from the detection level in the southern part of the pit, the filling acquires a more non-homogeneous nature: the soil becomes lighter to light brown in colour, the structure is coarser and the inclusions decrease. Layers of burnt clay destruction debris and ash appear. The layer next to the bottom is grey and homogeneous; its texture is loose and mixed with charcoal. Pottery fragments and animal bones occur in a high concentration. Burnt destruction debris was registered within the filling, mostly of a large size (up to 0.20 x 0.25m), as well as a fragment of a quern, eight flint artefacts and four stone pounders.

Pit 63 (Karanovo III/IV)

The pit is located within the area of sq. M12, M13, L12 and L13. The western half of the pit remains outside the boundaries of the survey area. It is irregularly oval in shape and about 2.20m in diameter. The bottom is uneven, reached at the depth of 0.50 to 0.60m from the detection level. The walls are slightly bevelled in depth. The filling is bright, beige-brown and non-homogeneous, containing ashy layers and spots of burnt organic material. Pottery fragments occur in a medium high concentration. Animal bones and a fragment of a quern were also found.

Pit 66 (Karanovo III/IV)

The pit is located in sq. M14. It is round in shape and 2.90m in diameter. The walls are comparatively regularly shaped, strongly bevelled in the upper 0.20 to 0.25m from the detection level, and smoother towards the bottom with two small pits dug into the latter. The filling is light grey-brown and loose, mixed with charcoal, small pieces of daub and alternating layers of ash, black burnt organic material and burnt destruction debris. The layer next to the walls and the bottom of the pit is more homogeneous: light brown clay soil with a higher density and significantly fewer impurities. Pottery fragments and animal bones occur in a high concentration in the upper levels of the filling and that become lower by depth. The filling contains several fragments of stone pounders, a large number of flint artefacts, walls of a grain storage pot, several fragments of fireplace coating and also an increased concentration of burnt daub mostly of a large size as most of them have a face surface. Two small pits were registered at the bottom. The eastern one has an elongated oval shape, measuring east/west 0.65m and north/south 1.00m. The southern one is oval in shape, measuring 1.20 x 1.30m. The fillings in both are the same as in the larger pit. It is exhausted at a depth of 0.30 and 0.35m from the detection level. The bottoms of both smaller pits are flat and the walls are slightly bevelled, almost upright.

Pit 67 (Karanovo III/IV)

The pit is located in the south-eastern sector of sq. L15. It is round in shape, 1.05m in diameter. The bottom is flat, reached at a depth of 0.40m from the detection level. The walls are almost vertical.

The filling is composed of non-homogeneous brown clay soil of a medium high density, containing spots of black burnt organic material and burnt destruction debris. In depth the soil

becomes brighter, and the concentration of daub decreases.

Pit 68 (Karanovo III/IV)

The pit is located at the borderline between sq. N15 and O15. It is oval in shape, measuring 1.90 x 2.20m. The bottom was reached at a depth of 1.10m from the detection level. It is flat, slightly sloping to the centre of the pit. Its diameter is 2.15m. The walls are well shaped; to a depth of 0.50m from the detection level and are upright, gradually expanding in depth. The filling is homogeneous dark grey and loose of a low density, mixed with small burnt destruction debris and crushed seashells. Pottery fragments occur in a medium high concentration. The filling contains a leg of an anthropomorphic figurine, about twenty flint artefacts, several pieces of copper ore (malachite) and some fragments of shells of white and black mussels.

Pit 69 (Karanovo III/IV)

The pit is located at the borderline between sq. N13–14 and O13–14. It is oval in shape, measuring 1.70 x 2.10m. The bottom is flat, reached at a depth of 0.70m from the detection level. The walls are bevelled in the western part and expand in depth in the eastern part of the pit. The filling is homogeneous, grey and mixed with charcoal and small pieces of burnt daub. Pottery fragments occur in a medium high concentration. The filling also contains animal bones, several flint artefacts, some pieces of copper ore (malachite), and small pieces of minerals, blue-purple in colour.

A Dug-In Structure

In the eastern sector a large dug-in area has been explored. It is of irregular shape (more than 80m^2). Its upper surface is covered with an ashy layer 2 to 5cm thick. The structure represents a complex system of many smaller pits reaching a depth of 1.20 to 1.30m. Its filling contains a huge amount of archaeological artefacts similar to those found in the rest of the pits.

Anthropomorphic Figurines from the Late Neolithic Features

From parallels with completely preserved figurines from other sites, we can reconstruct the method of making the sitting and standing figurines. These were made in parts, connected by means of a small pin. The head and the torso are shaped like an elongated cylinder. Bud-like ears and nose are attached to its upper part, and the arms are two semi-circles added to its lower part. Bud-like breasts are applied to the torso. The legs and seat are formed as left and right halves, which are then stuck to each another. Sitting figurines also have two extra little legs, which are shaped separately and then attached to the lower part of the pelvis. The figurines are coated with a layer of clay and then smoothed. In this manner the connected parts appear as one (Hansen 2004, 195 f.).

140 ceramic anthropomorphic and one stone (marble?) figurines are known from the site. Only one ceramic figurine was found intact and the other 139 are fragments of various parts of the body.

Stone Anthropomorphic Figurine

The stone figurine appears to be intact. A small part of it has broken off, probably in an attempt to perforate a hole in one end of the body. One can notice that the hole has not been achieved entirely. However, the presence of this changes the function of the figurine. Bearing in mind its size and shape, it can be interpreted as a stone pendant (*fig. 8*).

Fragmented Anthropomorphic Figurines

Fragments of cylindrical heads: 25 pieces of a similar size, the surviving parts vary in height from



Fig. 7. Small finds from Late Neolithic features at Akladi Cheiri.

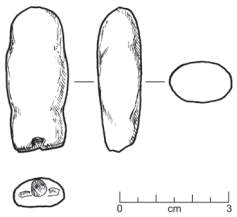

Fig. 8. Strongly schematised anthropomorphic figurine from a Late Neolithic feature at Akladi Cheiri (h: 4.90cm).

3.7 to 5.5cm and in diameter from 1.4 to 2.2cm. Only one larger fragment is distinguished, surviving up to 8.5cm in height. The spot where the neck is broken expands at the sides, giving us grounds to believe this is the entire length of the head (*fig. 9*). The fragments of cylindrical heads are divided into two groups according to the iconography of the face. The first group is represented by two fragments (*fig. 10–11*). Their nose and ears have not been smoothed and it is clear they were

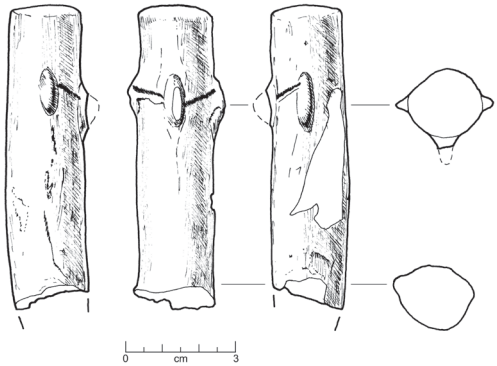

Fig. 9. Head of an anthropomorphic figurine from a Late Neolithic feature at Akladi Cheiri (h: 8.50cm).

attached to the cylindrical head. All the rest of the fragments belong to the second group (*fig. 7: 4; 12*). They have a beak-like nose that looks drawn from the cylindrical head rather than attached to it. The ears are smaller than the nose and probably have also been drawn. The eyes are similarly depicted in both groups.

Fragments of Torso with Semi-Spherical Arms

19 fragments of torsi were found. The arms are schematically shaped as two semi-circles and attached to a flat body with breasts also attached (*fig. 13*) (Вайсов 1993, 200).

Fragments of Torso with Schematically Rendered Anatomical Parts

The number of fragments found of this group is 22. Female figurines prevail with breasts attached to the torso. Ten of the fragments are broken in such a way that the sex could not be determined. Two of them have vertical parallel cuts on one of the wider sides in the lower half of the torso where the legs are supposed to be. Two fragments with male gender signs have been also found. In height, between 2.5 and 7.5cm of the torso are preserved. Without exception, the heads are broken and missing. The breaking point has a circular horizontal section between 0.8 and 1.6cm in diameter, and a larger fragment 2.3cm in diameter.

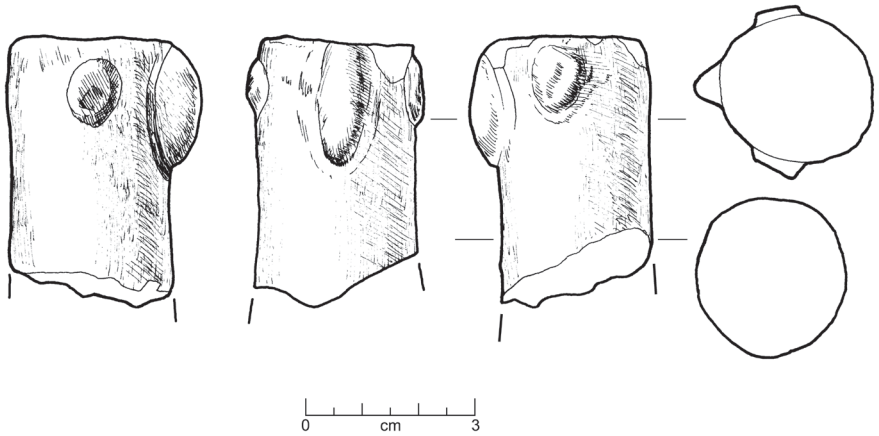

Fig. 10. Head of an anthropomorphic figurine from a Late Neolithic feature at Akladi Cheiri.

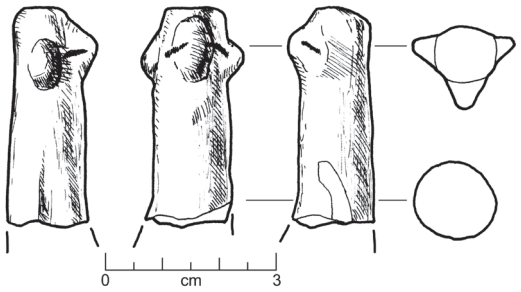

Fig. 11. Head of an anthropomorphic figurine from a Late Neolithic feature at Akladi Cheiri.

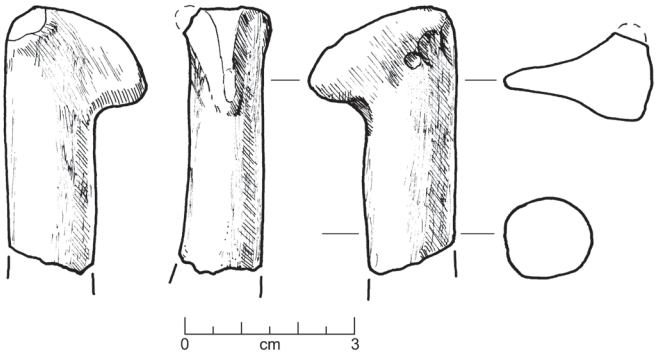

Fig. 12. Head of an anthropomorphic figurine from a Late Neolithic feature at Akladi Cheiri.

Fragments with Legs/Pelvis

60 fragments of the lower part of the body belonging to figurines sitting on legs/pelvis were found (Berger 2004, 178). Thus modelled, they have four pivot points: two for the feet and two for the short legs attached to the pelvis. The legs are solid, folded at the knees, and the legs at the back give extra stability. One fragment displays the sexual triangle outlined by shallow incisions.

Fragments of Legs and Pelvis

There are two pieces. These are preserved 4.7cm in height. They have been broken in a similar manner and present the same part of the body/pelvis with the left hip and a small part of the torso. The seat strongly protrudes outwards and the legs are slender and cylindrical, separated by a vertical incision line. Both fragments possess a hemispheric growth which can be interpreted as

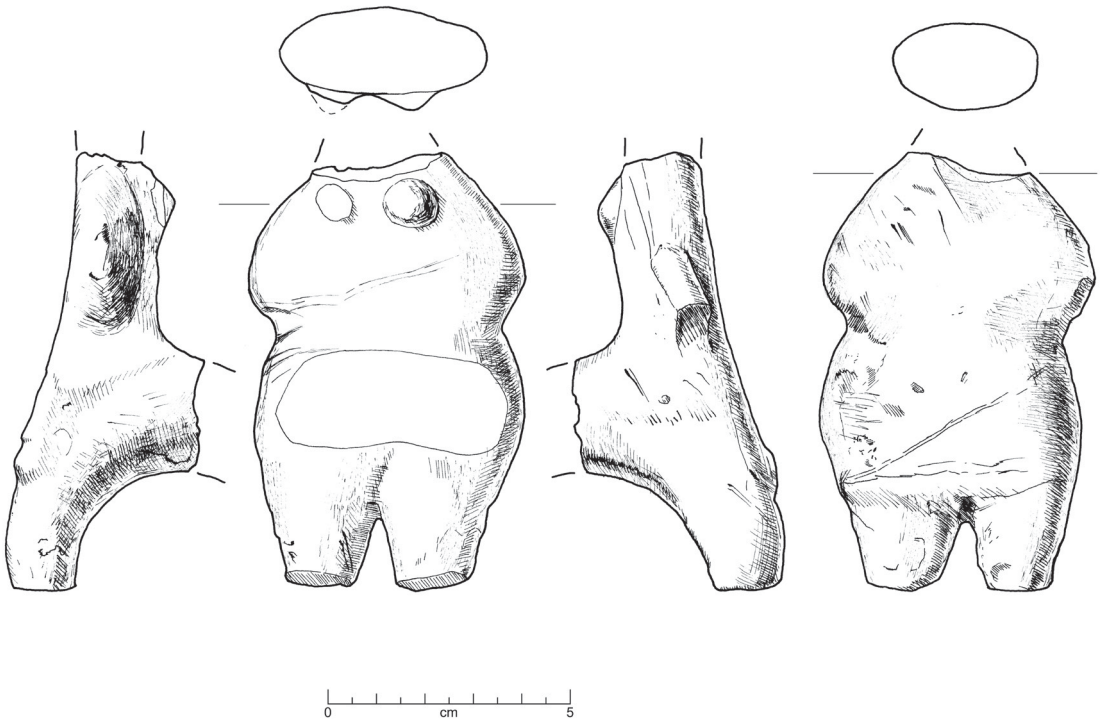

Fig. 13. Torso of an anthropomorphic figurine from a Late Neolithic feature at Akladi Cheiri.

an arm or hip thickening. The sexual triangle is outlined by a shallow incised line; one of the fragments bears traces of white inlay.

Due to their small size and severe damage, several fragments cannot be attributed to any of the above groups.

Typology

Some of the best preserved fragments found at Akladi Cheiri, have parallels with samples from other sites, enabling three types of ceramic anthropomorphic figurines to be made:

Sitting on the Legs/Pelvis (Type of Sitting, Sub-Type of on Legs/Pelvis)

Anthropomorphic figurines with cylindrical heads, a torso as a natural prolongation of the head with adherent hemispherical arms and attached breasts. Their size varies as they have obviously been produced from small (h: 10 to 13cm) to large (h: >18cm) figurines of this type. The eyes are missing or have been rendered with two near-horizontal incised lines. As we have mentioned, binding fragments are not detected and therefore it is difficult to determine whether all head fragments belong to sitting anthropomorphic figurines. However, in shape, size and iconography, the known heads correspond to the stylistic features of this sub-type.

Figurines with Schematically Depicted Anatomical Features

The body has been shaped out of a single piece of clay and the individual parts are not differentiated. The shape of some of these resembles loom weights. The vertical section of these figurines is trapezoidal or rectangular, expanding slightly at the lower side. The small diameter at the base of the head suggests that it was not solid. We can assume that the size of the schematic figurines is between 7 to 15cm.

Standing Figurines with Hyperbolised Backs

The type is represented by two fragments. The surviving parts allow them to be related to the standing type of figurines with the sub-type of hyperbolised shape of the body. Both fragments are quite small and do not give information about the proportions of the body or the shape of the head.

The Late Neolithic anthropomorphic figurines from the site discussed here can be distinguished into three types, fragments of which appear in closed complexes. This means that all three types existed and were developed in parallel. The figurines sitting on legs/pelvis are the highest in intensity, followed by the schematically presented ones and the standing samples. Only one entirely preserved figurine was found on the site. It belongs to the group of schematically rendered shapes which favours the exploration and understanding of fragments of the same type. The remainder of the samples are fragmented. The fractures are in places in which the separately modelled parts of the body are constructively connected, which probably has semantic significance. The fragments of cylindrical heads can be related to each of the three types, that is, they are not a factor defining the type. They represent the iconographic tradition of heads during the period in question. We can distinguish two methods of shaping the body. In the schematic figurines the torso and the legs are rendered together and do not seem to require special skills in modelling. They do not show canonical or formal repeatability. Both male figurines of this type display a difference in marking the sexual indicators. The other type is the sitting figurines. They are various in size but with preserved proportions. Exact parallels for the figurines sitting on legs/pelvis have not been found in a Late Neolithic context. It seems interesting to note, that within the Chalcolithic layer in Sitagroi (Phase III) there is a fragment of a figurine sitting on legs/pelvis which is closest to the ones found at Akladi Cheiri (Hansen 2007, Taf. 203: 4). Its surface is red and a linear decoration has been laid with black paint on it.

The anthropomorphic figurines from the period of Karanovo III/IV in Thrace are standard and canonical. As a result of studying the samples from Akladi Cheiri we can say with great certainty that to the east the roads of cultural impact from the interior of Thrace extend directly to the Black Sea coast. The question of whether the north-eastern boundary of the area and the contact zone between the Hamangia Culture and the Thracian traditions in the depiction remains open.

The Middle/Late Chalcolithic Features (4500 to 4000/3900 BC)

A layer of 0.20 to 0.30m was registered to belong to the Chalcolithic Period. It relates to the Early Chalcolithic and contains a large number of dug-in structures (from both Early and Late Chalcolithic). The pits are of a regular oval or round shape and at a depth up to 1.50m. In them archaeological artefacts were deposited, mainly fragmented pottery and other objects in smaller numbers.

Pit 2 (End of the Early/Beginning of the Late Chalcolithic)

The pit is located in the eastern sector of sq. J7 and the western sector of sq. I7. It is oval in shape, measuring 2.20m north/south and 3.00m east/west. Its walls are slightly bevelled, and the bottom flattened, reached at a depth of 1.50m from mR (15cm from the detection level).

The filling is composed of light grey-brown clay soil, loose in structure and mixed with small pieces of charcoal.

Pottery fragments occur in a high concentration. The shapes relate the pit to the end of the Early to the first half of the Late Chalcolithic.

Besides the pottery fragments, the pit also contains animal bones, several flint artefacts, small pieces of malachite ore, a stone pounder, a fragment of a ceramic anthropomorphic figurine and two fragments of ceramic disks.

Pit 3 (Late Neolithic/Chalcolithic?)

The pit/granary is located in the central northern sector of sq. I6. It is round in shape and 0.90m in diameter. Its walls are almost vertical, and the bottom is flattened, reached at a depth of 0.65m from the detection level (0.75m from mR). The longitudinal section is cylindrical. The filling is composed of yellowish-ochre grizzly clay soil mixed with small pieces of daub and charcoal. The walls are coated with yellowish-ochre clay, up to 3 or 4cm thick.

The concentration of pottery fragments is low. The registered shapes relate the pit to the Late Neolithic, but the surface of the fragments is peculiar to the Chalcolithic.

The filling contains a single animal bone and ten to 15 mainly small and rounded stones.

Pit 4 (Late Early-Early Middle Chalcolithic)

The pit is located in the southern sector of sq. H11 and the eastern sector of sq. H12. It is elongated and slightly rectangular in shape. Its corners are rounded, measuring 2.20m north/south and 1.70m east/west. The eastern part of the pit has been destroyed by a trench for a modern building. The walls are nearly vertical, and the bottom is flat, reached at a depth of 0.50m from the detection level (0.86m from mR). The longitudinal section is almost cylindrical.

The filling is composed of brown-ochre homogeneous clay soil, mixed with small pieces of charcoal.

Pottery fragments occur in a high concentration (mostly large in size). The registered shapes relate the pit to the Early and up to the beginning of the Middle Chalcolithic.

The filling also contains animal bones, two flint artefacts and several small pieces of malachite ore.

Pit 5 (Late Neolithic/Early Chalcolithic)

The pit is located in sq. G12, 20cm west of pit 4. It is round in shape and 0.80cm in diameter. The walls narrow slightly in depth, and the bottom is flat, reached at a depth of 0.60m from the detection level (0.96m from mR). The longitudinal section is of an inverted truncated conical shape.

The filling is composed of light grey-brown clay homogeneous soil mixed with small pieces of charcoal.

Pottery fragments occur in medium high concentration (mostly small in size and indistinctive). The filling also contains single animal bones (rather fragmented), two fragments of daub of a fireplace and a flint fragment.

Pit 9 (Early Chalcolithic)

The pit is located in sq. J7, next to the north-east/south-west profile of the site. It is round in shape, 0.65m in diameter. Its south-eastern half is beyond the area of research. The walls and the base are plastered with a layer of beige-ochre clay, 1 to 2cm thick. The bottom is flat, reached at a depth of 0.30m from the level of detection.

Pottery fragments occur in a high concentration. According to the registered shapes and decoration, the pit dates to the Early Chalcolithic.

The filling also contains animal bones, some small pieces of malachite ore, a horn tool and a stone adze.

Pit 10 (Late Early-Early Late Chalcolithic)

The pit is located in the northern sector of sq. H9. Its northern and eastern parts have been destroyed by modern building activities. It is round in shape, 2.50m in diameter in the south-east/north-west direction (the surviving part). Its western and southern walls are bevelled; the bottom is a bit concave, reached at a depth of 0.75m from the detection level (1.49m from mR).

Several stages of filling were registered. From the bottom up they are as follows:

The layer just above the bottom is sandy in nature and of a coarse structure, occasionally mixed with crushed daub and charcoal. Its thickness is 0.10 to 0.15m. The filling at this level contains 16 pieces of burnt clay destruction debris, some of them baked to melting, and also several stones, round in shape and small in size (up to 10cm). Pottery fragments occur in a low concentration;

among them two large walls of a pithos and a fragment of a thick-walled vessel, strongly burned to deformation and melting, were registered.

From 0.40 to 0.60m from the detection level the filling is composed of clay, sand non-homogeneous soil mixed with beige-ochre layers and black spots and layers. The latter represent slightly burned clay of a non-compact structure, up to 5cm thick. They are concentrated mainly in the central and northern part of the pit. The black spots are probably remains of charred organics. The filling at this level contains a high concentration of charcoal, reaching up to 4 x 6cm in size. Some burnt destruction debris of a compact structure was also found there, as well as two flint artefacts, a stone axe and a fragment of a quern.

The filling from the surface down to 0.40m is homogeneous, composed of grey-black clay soil mixed with small pieces of daub and charcoal. Pottery fragments and animal bones registered at that level occur in a high concentration.

Pit 11

The pit is located in sq. H10 and G10. It is irregularly oval in shape, elongated in the south-east/north-west, measuring 0.65 x 0.75m. Its walls are almost vertical. Slightly concave, the bottom is flattened. Vertically, it has a slightly pronounced barrel-like section. The bottom was reached at a depth of 0.30m (0.95m from mR).

The filling is homogeneous and brown, comparatively loose, containing clay and mixed with small pieces of daub and charcoal. Pottery fragments occur in a low concentration. Single animal bones and two flint artefacts were also found.

Pit 13 (Early Chalcolithic)

The pit is located in the northern sector of sq. H10 and the southern sector of sq. H9. It is oval in shape and 2.70m in diameter. The walls are almost vertical in their upper part, expanding by depth. The bottom is flat, reached at a depth of 0.60m from the detection level (1.36m from mR). The longitudinal section of the pit has a truncated, bell-like shape. Its eastern and north-eastern sides have been destroyed by modern building activities.

Two levels of filling were distinguished:

The filling from the bottom to 0.40m is composed of grey-brown clay, comparatively loose soil mixed at times with small pieces of daub and charcoal.

From 0.40m to the surface the filling is brighter and sandy, with less inclusions of small destruction debris and charcoal. At this level, pieces of burnt destruction debris (ten to 15, orange-red in colour), about 17 fragments of face daub of a fireplace/furnace and several small rounded stones were registered.

Pottery fragments and animal bones occur in a high concentration. Six flint artefacts, a stone pounder, a fragment of a stone tool, two ceramic disks, a fragment of an altar (a cult table), and some small and one large piece of malachite ore were also found.

Pit 24 (Chalcolithic)

The pit is located in the south-western sector of sq. F17. It is round in shape, 0.50m in diameter. Its walls are vertical; the bottom is flat, reached at a depth of 0.25m from the level of detection.

The filling is composed of dark brown clay soil of a medium high density. At times whitish spots of clay texture appear. Archaeological artefacts are almost missing and there are only a dozen pottery fragments.

Pit 27 (End of Early to Beginning of the Late Chalcolithic)

The pit is located in the north-western sector of sq. G16. It is oval in shape, measuring 1.20m east/west and 1.10m north/south.

The filling is composed of grey-black clay soil of a medium high density. At times concentrations of small pieces of charcoal and daub appear as well as whitish spots of clay texture. The pit contains a high concentration of pieces of iron and copper ore, measuring from 0.5 and 1.0 to 8.0 and 10.0cm. The concentration of pottery fragments is medium high.



Fig. 14. Akladi Cheiri. Overview over the Late Chalcolithic pit 28.

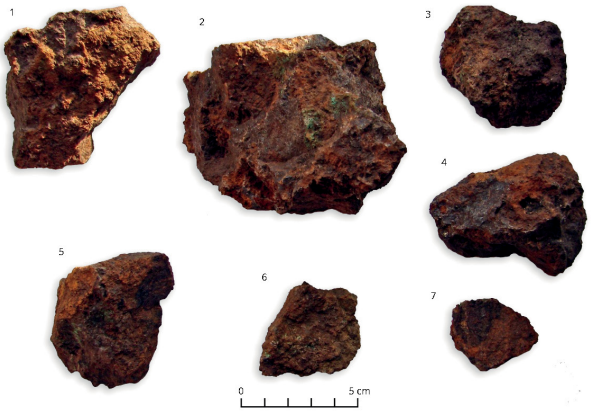

Fig. 16. Akladi Cheiri. Pieces of copper ore from pit 28.



Fig. 15. Akladi Cheiri. Late Chalcolithic ceramic vessel with traces of secondary burning on the inner surface. From pit 28.

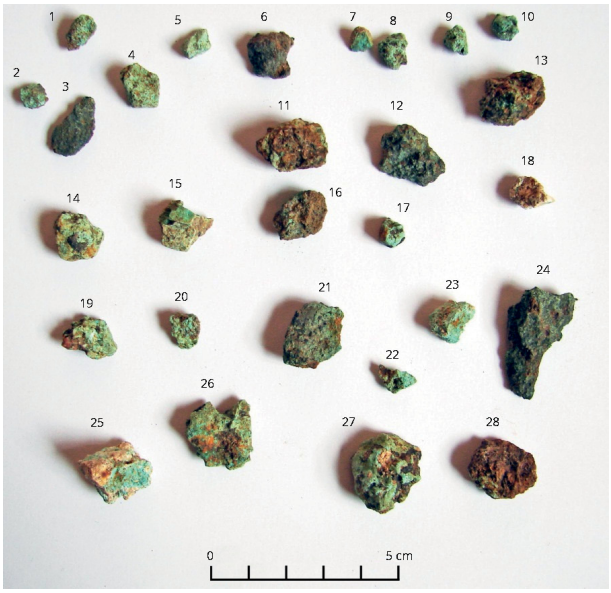

Fig. 17. Akladi Cheiri. Malachite pieces from pit 28.

Pit 28 (End of the Late Chalcolithic)

The pit is located in the south-eastern sector of sq. G20. It is oval in shape, measuring 2.17m north/south and 2.40m east/west (*fig. 14*).

The filling is composed of dark brown clay soil, saturated with many small pieces of daub. Spots of red burnt clay were registered next to the boundaries of the pit, in the western and southern direction. A pile of secondary fired pottery fragments, medium in size, appear at a depth of 0.30m from the detection level (*fig. 15*). They belong to more than one pot. Two whole miniature vessels were also found in the pile. The fragments lie mainly horizontally and occasionally vertically, and at the periphery of the pit they are slightly inclined following its walls. Among them small stones and a piece of copper ore are also present (*fig. 16–17*). The pile is concentrated in the western half of the pit, measuring 1.70m north/south and 0.80m east/west. In the eastern half of the pit a further pile of non-processed stones small and large in size, several pottery fragments and a piece of daub appears (*fig. 18–20*). It measures 0.80m north/south and 0.60m east/west. Both easternmost stones are attached to one another. A third stone lies 0.15m west of the second stone, and a fourth about 0.30m east of it. All of the stones come from querns. Between the two piles are fragments of a ceramic structure, burned strongly to melting (*fig. 21*). It



Fig. 18. Akladi Cheiri. Late Chalcolithic ceramic sherds with incised decoration. From pit 28.

bears traces of copper and iron oxides (*fig. 19–22*). The thickness of its walls is 5 to 8cm. Both outer walls of the structure are roughly smooth. Most probably the structure was oval in shape. Its base is flat and about 0.09m thick. The thickness of the walls of the fragments is about 4 to 5cm. The preserved height of the structure is about 0.15m.

Pit 29 (Chalcolithic?)

The pit is located in sq. E16. It is elliptical in shape, measuring 2.30m north/south and 1.40m east/west. Part of the pit is under the profile and remains unexplored.

The filling is grey-black and loose, saturated with small pieces of charcoal and tiny pieces of daub. In the northern half, 0.20m from the detection level a whitish spot with the appearance of a clay structure mixed with small pieces of charcoal and daub. Pottery fragments and animal bones occur in a medium high concentration.

Pit 34 (Posthole)

The pit is located at the borderline between sq. F13 and E14. It is elliptical in shape, measuring 1.48m east/west and 1.24m north/south. The bottom is

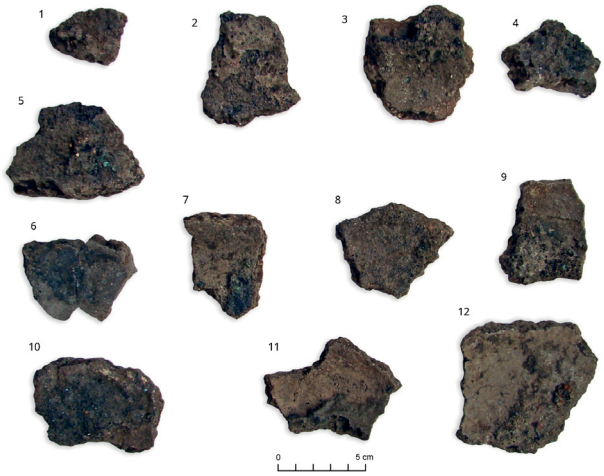

Fig. 19. Akladi Cheiri. Late Chalcolithic ceramic sherds with adherent slag residues probably from metallurgical processes. From pit 28.

flat, reached at a depth of 1.10m from the level of detection.

The filling is grey-brown in colour and of a low density. Pottery fragments occur in a low concentration. Four to five animal bones were found, as well as four to five flint artefacts. Possibly the pit was formed from an angular bearing pole connected with a spot of burnt destruction debris in sq. E14. 2.30m northwest of pit 34 a further posthole was registered. It is oval in shape, measuring north/south 0.50m and east/west 0.65m. Vertically,

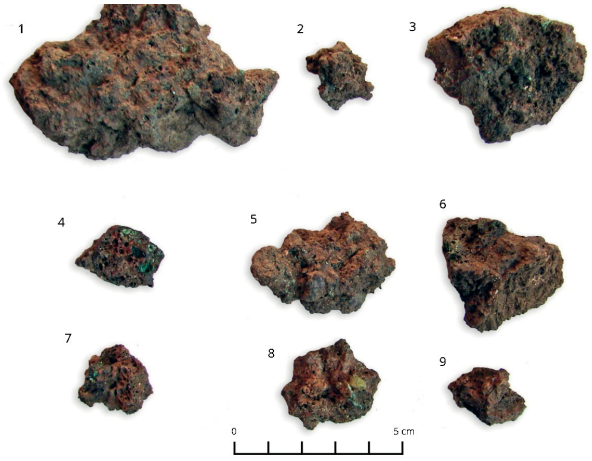

Fig. 20. Akladi Cheiri. Slags from pit 28.



Fig. 21. Akladi Cheiri. Large ceramic fragment with traces of secondary burning and adherent slag residues from pit 28.



Fig. 22. Akladi Cheiri. Large ceramic fragment with traces of secondary burning and adherent slag residues from pit 28.

it has a cylindrical shape, narrowing slightly at the base and continuing to a depth of 0.45m from the detection level. Its filling contains small pieces of charcoal and destruction debris.

Pit 38 (Late Early – Early Late Chalcolithic)

The pit is located in the central part of sq. H21. It is elliptical in shape, oriented north-east/south-west and measuring 2.60 x 2.30m. The bottom is flat, reached at a depth of 0.80m from the level of detection.

The surface of the pit is marked with a pile of pottery fragments and stones. The fragments belong to a bowl. There is a stone inside it with no traces of being used and a large stone pounder. A stone tool was found immediately to the north of the bowl and had been reused as a pounder.

The filling is brown-grey, loose and sandy, with a high concentration of small pieces of charcoal. In the north-western part of the pit, at a depth of 0.30m, a further pile appears made of fragments of some pots. Several pieces of burnt daub, some of which originated from a furnace, were registered at a depth of 0.50m in the north-eastern part of the pit. The filling also contains a stone tool and several flint artefacts.

Pit 41 (Early Chalcolithic?)

The pit is located in sq. H21–22 and I21–22, disturbing pit 38. It is elliptical in shape, oriented north-east/south-west, measuring 3.00 x 2.50m. The south-eastern part of the pit had been destroyed by pit 42.

The filling is grey-brown, loose and sandy; some darker spots can occasionally be distinguished. At a depth of 0.30 to 0.40m in the north-eastern part of the pit a level of burnt destruction debris was reached, compactly positioned next to each other. The soil between them is beige-brown in colour. The concentration of pottery fragments and animal bones is highest in the south-western part of the pit, and in the north-western part some large crushed stones were revealed.

Pit 42 (Late Chalcolithic)

The pit destroyed the south-eastern part of pit 41. It is round in shape and 0.90m in diameter. Its longitudinal section has an inverted conical shape. The bottom is flat, 1.10m in diameter, and is reached at a depth of 0.95m from the level of detection.

The filling is composed of brown loose clay soil containing a high concentration of small pieces of charcoal. At a depth of 0.50 to 0.55m from the detection level a layer of crushed boulders was registered. It could be traced along the entire area of the pit. Pottery fragments occur in high concentration, decreasing towards the bottom.

Pit 50 (Chalcolithic)

The pit is located in sq. N17. The filling from the level of detection down to 0.40m is composed of

brown clay soil of a high density and mixed with small pieces of burnt destruction debris and charcoal. Pottery fragments occur in a medium high concentration. Single animal bones also appear, as well as some flint artefacts and a bone object.

At a depth of 0.40m from the detection level the features of the filling change: the soil becomes homogeneous, dark brown, of a looser structure and lower density. The inclusions of small pieces of daub, charcoal and stones disappear, similar to the upper levels of the filling.

At a depth of 0.60 to 0.80m from the detection level the filling occasionally contains concentrations of charcoal, and yellowish sterile inclusions also appear. Pottery fragments at this level occur in a low to medium high concentration. Single small animal bones are also present.

At a depth of 0.70m from the detection level the pit narrows in its northern part through a stepped outset, 0.40 to 0.60m wide. At this level groundwater flows. The filling keeps its features by depth, but the concentration of artefacts increases significantly. The pottery fragments registered are larger in size and their surface is comparatively well preserved. Animal bones were found in a very high concentration.

At a depth of 1.10m from the detection level a second pit was registered: 50A.

Pit 51 (Late Chalcolithic)

The pit is located in the central eastern part of sq. N16. Its eastern periphery is within the boundaries of sq. O16. The pit is of an irregularly oval shape and irregular section, measuring 1.95m north/south and 2.50m east/west. The eastern wall is oblique, the northern wall almost upright, and the western and southern walls concave. The bottom is flat, reached at a depth of 0.50m from the level of detection.

The filling is composed of dark brown clay compact soil of a high density and mixed with small pieces of crushed daub and charcoal. It becomes slightly brighter by depth and more homogeneous and looser. Pottery fragments occur in a medium high concentration. Animal bones, some flint artefacts and five fragments of stone tools were also found. At a depth of 0.30m from the detection level two pieces of copper ore (malachite) were registered.

Pit 52 (Chalcolithic?)

The pit is located in the north-eastern sector of sq. N15. Its eastern and northern peripheries are within the boundaries of sq. O15 and N16. The pit is oval in shape, measuring 2.00m north/south and 2.30m east/west. The bottom is reached at a depth of 1.40 to 1.45m. Down to a depth of 0.70m from the detection level the walls are irregularly shaped, upright to slightly oblique, expanding in depth and thus the pit acquires a slightly pronounced bell-like cross section.

The filling is composed of dark brown clay soil, mixed with small pieces of crushed daub, charcoal and gravel. The soil becomes slightly brighter and less dense, by depth and the inclusions decrease. At a depth of 0.10 to 0.25m of the detection level two fragments of querns were revealed next to the western wall of the pit. Dark grey-brownish spots of burnt clay (fuzzy) were registered at a depth of 0.80 to 1.20m from the detection level. In the central part of the pit at a depth of 0.90 to 1.00m from the detection level a grinding stone measuring 0.25 x 0.35m was revealed.

Pottery fragments occur in a high concentration. Most of the animal bones (including an antler) found belong to large animals. The filling contains about twenty crushed stones of small and medium size, two fragments of stone tools, nine small pieces of copper ore (malachite), two pieces of limonite, a piece of hematite (?), and five flint artefacts.

Pit 53 (Early Chalcolithic)

The pit is located at the borderline between sq. L13–14 and M13–14. It is round in shape and 1.40m in diameter. Its north-eastern periphery partially destroys a further smaller pit, located in the south-western sector of sq. M14. The walls are well shaped and upright. The bottom is flat, reached at a depth of 0.45m.

The layer next to the bottom is light brown in colour, containing spots and inclusions of small pieces of charcoal of a medium high concentration



Fig. 23. Akladi Cheiri. Overview over the Early Chalcolithic pit 54.



Fig. 24. Akladi Cheiri. Detail of Early Chalcolithic pit 54 with ceramic vessel and a copper pin *in situ*.

and a low concentration of daub. A fragment of a grinding stone was revealed lying on the bottom with its working surface face down.

The filling up to the level of detection is composed of grey-brown clay soil mixed with small pieces of daub. At a depth of 0.35 to 0.40m from the detection level, fragments of an Early Chalcolithic bowl with cord-like handles were revealed *in situ* directly against the wall. A fragment of an animal jaw was lying below the bowl. Fragments of a further bowl were found next to the southern wall, and below these a piece of iron ore. A stone pounder and an animal bone were found next to the eastern wall. In general, the materials were concentrated next to the walls of the pit.

Pit 54 (Early Chalcolithic)

The pit is located in sq. H22. It is round in shape and 0.70m in diameter. The pit is shallow, regular in shape and the walls are smooth, with a hemispherical section (*fig. 23*).

Its surface is marked by a pile of pottery fragments belonging to a single pot (*fig. 24–25*) with a copper pin next to them (*fig. 26–27*). Among the fragments five stone tools, four pounders and a semi-manufactured pounder were present. The pottery fragments cover the entire surface of the pit relatively evenly and tightly. Those around the periphery lie slightly sloping inwards towards the centre.

The filling is dark brown and loose, mixed with small pieces of daub in a low concentration. The bottom is reached at a depth of 7 to 8cm below the level of the fragments.

Pit 61 (Early Chalcolithic)

The pit is located in the north-western sector of sq. O14 and the north-eastern sector of sq. N14. It has a regular oval shape, measuring 2.25m north/south and 2.05m east/west. The bottom is flat, reached at a depth of 1.20m from the detection level. Its diameter is about 2.10m. The walls are regularly formed and nearly vertical. The section of the pit is cylindrical; the walls are slightly rounded towards the bottom. In its upper two thirds the pit is dug into the filling of a Late Neolithic dug-in structure and further down into the sterile base (brown-yellowish clay layer of a medium-coarse texture).

The filling is homogeneous, grey-brown and of a loose clay structure, mixed with small pieces of charcoal and daub.

Pottery fragments occur in a medium high concentration. Animal bones, in excess of ten flint artefacts, a large piece of copper ore (malachite), three seashells, a stone weight, a fragment of a quern of small size, and two fragmented stone pounders were also present.

Pit 64 (Late Chalcolithic)

The pit is located at the borderline between sq. N12 and N13. It is round in shape and 2.90m

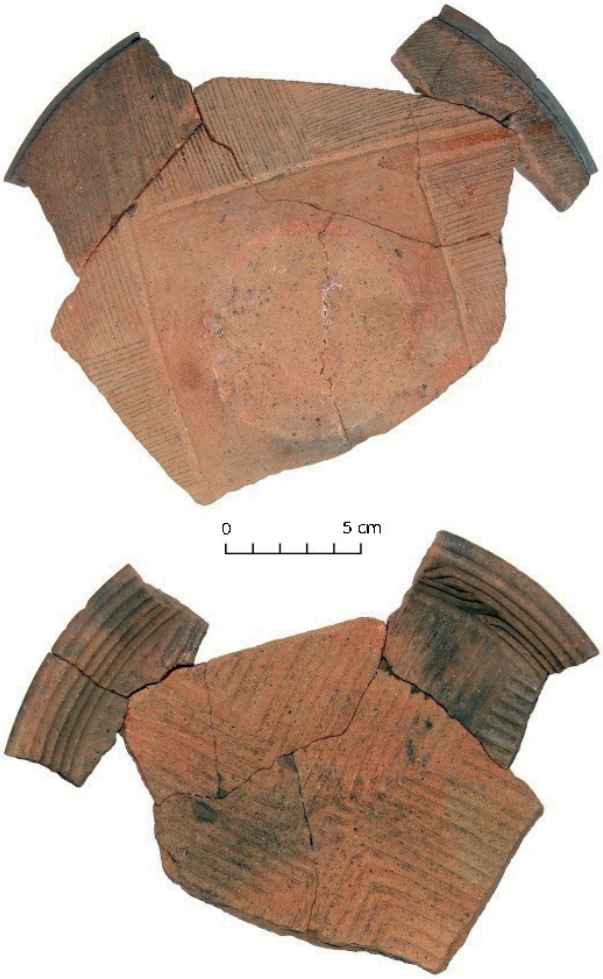

Fig. 25. Akladi Cheiri. Two Early Chalcolithic vessels with incised decoration from pit 54.

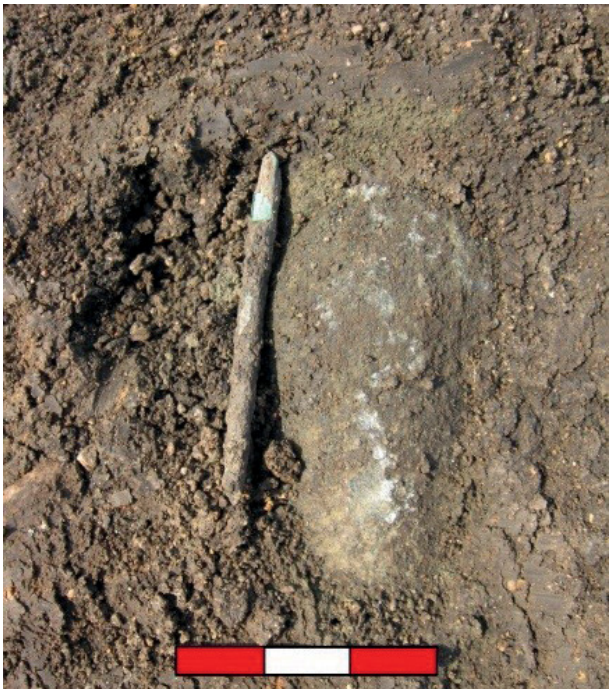

Fig. 26. Akladi Cheiri. Detail of the find context with copper pin in the Early Chalcolithic pit 54.

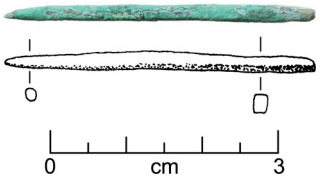

Fig. 27. Akladi Cheiri. Copper pin from the Early Chalcolithic pit 54.

in diameter. The bottom is flat, reached at a depth of 1.10m from the detection level. Its diameter is 2.50m. The walls are regularly shaped, almost upright in the upper 0.30m from the detection level, and slightly expanding by depth. The longitudinal section is inverted conical in shape.

The filling from a depth of 0.70m to the bottom is grey, more compact and clay texture, slightly mixed at times with light brown clay spots. At this level the concentration of artefacts sharply decreases and only four shells of black mussel were found.

The filling up to 0.70m from the detection level is grey-brown, loose and homogeneous, mixed with small pieces of charcoal and burnt daub. Pottery fragments occur in a high concentration. Animal bones, several fragments of smoothed stone tools, a fragment of a ceramic anthropomorphic figurine, and a head of a cylindrical idol, were also found.

Pit 65 (Chalcolithic?)

The pit is located in the central southern sector of sq. N14. It is round in shape and 1.95m in diameter. The bottom is flat, reached at a depth of 0.50m from the level of detection. Its diameter is 1.60m. The walls are bevelled and well-shaped. The longitudinal section is inverted truncated conical in shape.

The filling is grey-brown, relatively loose and of a medium high density, mixed with charcoal. Pottery fragments occur in a medium high concentration. The pit also contains animal bones, a stone pounder, a fragment of a quern, three flint artefacts, and copper (malachite) and iron ore.

Prehistoric Burials of the 4th Millennium BC

In the course of the archaeological excavations five graves and several disarticulated human bones were revealed. Graves 1, 4 and 5, as well as the disarticulated human bones relate to the 4th mill. BC. Two other graves are recent, most probably from the 19th cent. AD. The buried individuals had been deposited in an extended position on their backs, oriented north-west/south-east. Grave N 2 had been dug to a depth of 0.50m from the modern surface. The pit is poorly identifiable. Its south-eastern part, the skeleton included, has been destroyed by a modern cable duct. In the thoracic region of the skeleton a metal button was revealed, and a second similar button, probably also belonging to the deceased, was found in the modern duct. Grave N 3 is similar in orientation to the one described above. It is a rectangular pit with a depth of 1.60m. The filling of the grave contained about ten nails, probably from a coffin. Above the skeleton eleven metal and four bone buttons were revealed, as well as three bronze fasteners. Some of the buttons have galloons preserved on them. Probably all of the artefacts found came from a military uniform. After the buttons were cleaned, poorly preserved English inscriptions could be seen on their reverse side. For the time being, we assume that both graves are from the 19th cent. AD and belonged to an officer and soldier of the Turkish or British Army.

Grave 1

Grave 1 is located in sq. H8. The burial pit had clear west, south and south-east boundaries and a less well determined outline in the north. Its orientation is south-west/north-east. The pit is 1.60m in length and about 0.70m in width (*fig. 28*). The filling is composed of grey-black clay compact soil of a relatively homogeneous structure with inclusions of small pieces of crushed daub. Pottery fragments in a low concentration were registered while revealing the skeleton (mainly small and indistinctive pieces) as well as some single animal bones, tiny pieces of plaster from a fireplace/oven, single small pieces of daub, a mussel shell and several small pieces of malachite ore. The bones of the skeleton appeared at a depth of 0.25 to 0.35m from the surface, and the skull 0.20 to 0.30m from the surface. The skeleton is almost entirely preserved although fragmented. The right temporal area of the skull is more fragmented, probably as result of soil pressure.

The deceased had been deposited in a contracted position on its back with the legs to the left. The head was oriented west to south-west with the face to the north. The arms were heavily contracted at the elbows and lay parallel to the vertebral column; the wrists were bent and pointed towards the skull, almost at right angles to the arm bones. The vertebral column was oriented towards the northwest. Femoral bones form a right angle with the axis of the spine, and the tibiae a sharp angle to the hip. The bones of the feet, as well as those on the palm (of only the left hand), are very well preserved. The skeleton is 1.13m long in total, and its maximum width is 0.63m.

Length of the limb bones: femur – 0.41m; tibia – 0.34m; humerus – 0.31m; ulna – 0.23m; radius – 0.24m; width of the pelvis – 0.29m. The highly contracted position of the upper and lower limbs suggests that they were tightly bound, probably almost immediately after death. Full skeletal development indicates that the deceased is an adult individual. The individual died between 35 and 39 years of age. The skeleton is not clearly sexually dimorphic. Some features of the skull indicate that he was male. He was probably a gracile man. His height was between 1.66 and 1.71m, with an average of 1.68m.

The left wrist, as well as the back of the skull show traces of green colouring, probably from contact with copper ore. When scraping the ground around the grave, a circular, flat bone object with a hole in the middle was found about 0.60 to 0.70m north of the skull (outside of the the burial pit).

A small spherically-shaped ceramic vessel, deposited next to the left femur, had been left as a grave good (*fig. 29*).

Grave 4

Grave 4 is located in sq. I22. The burial pit could not be identified. Only a fragment of the vertebral column, pelvis and parts of the left and right

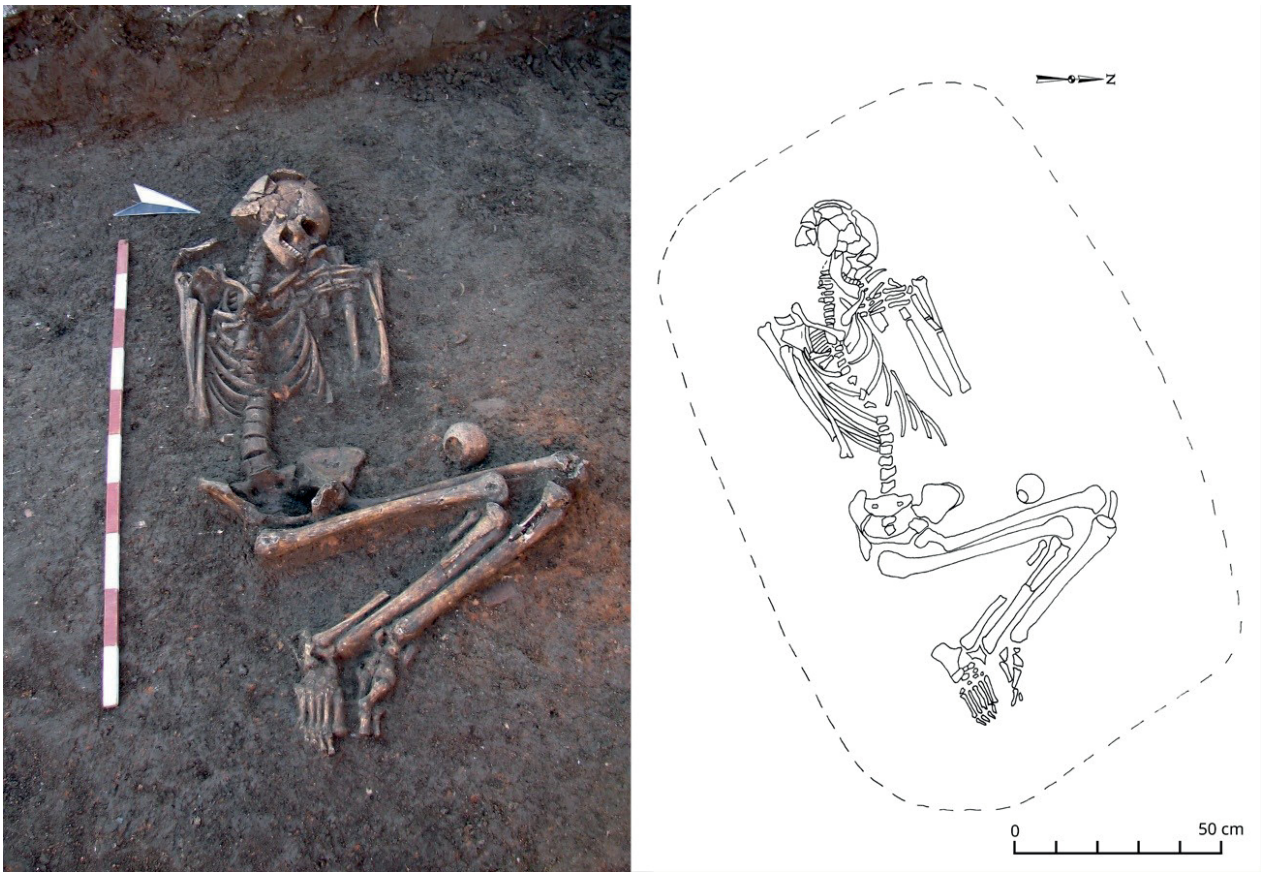

Fig. 28. Akladi Cheiri. Photograph and drawing of grave 1 from the 4th mill. BC.

femur have survived (length respectively 0.08m and 0.20m). Partially preserved left and right *tibiae* and *fibulae* and some of the bones of the ankles were revealed in situ, 0.14m south of the left femur. Perhaps it is a burial in crouched position to the right or on the back, with legs flexed at the knee (*fig. 30*). The length of the revealed skeletal remains is 0.54m in total. Skeletal development indicates that this was an adult individual although it is not possible to precisely determine age. Based on the morphology of the pelvis, it is probably a female. No grave goods were found.

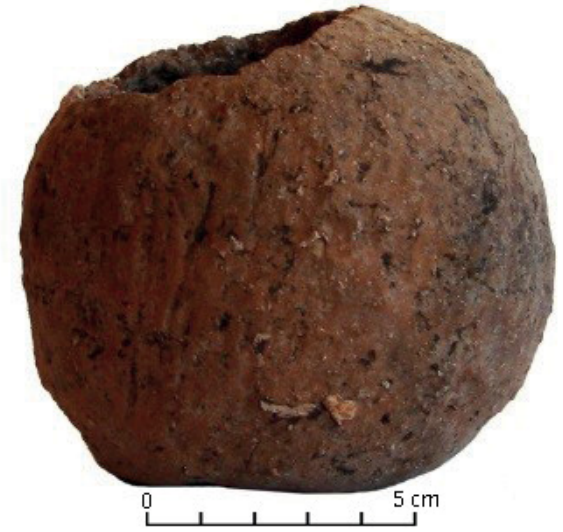

Fig. 29. Akladi Cheiri. The vessel from grave 1.

Grave 5

Grave 5 is located in sq. I22. The burial pit could not be identified. The skeleton was lying within a layer of dark brown soil, saturated with pieces of burnt daub, red-black in colour (*fig. 31*). Coordinates from the skull: south 4.23m, west 3.23m.

The remains are from a child. The skeleton was in a contracted position to the left, with the legs tightly bent at the knees. The right leg forms almost a right angle to the body, and the left is even more contracted. The skull is oriented north-east, with the face to the south/south-east. The skeleton is not well preserved as the bones are very fragile. The skeletal remains are 0.54m long



Fig. 30. Akladi Cheiri. Overview of the burial in crouched position in grave 4 without grave goods.

Fig. 31. Akladi Cheiri. Overview of the burial in crouched position in grave 5.



Fig. 32. Akladi Cheiri. Two ceramic vessels from grave 5.

in total. The skull with the mandible, one of the *humeri* and both femurs survived almost complete. Based on the size and texture of the bones, it is clear that they belong to a child. Dental development and the length of the *humerus* indicate that the age at which death occurred was between five and seven years.

In front of the forehead a ceramic vessel was revealed, lying on its base and slightly inclined from north-east to south-west. The diameter of the vessel mouth is 8.5cm; the diameter of the bottom is 5cm. In front of the *humerus* a further vessel appeared, left of the mouth and face down. The diameter of the mouth is 11cm; that of the bottom 7cm (*fig. 32*). No other grave goods were found.

In sq. G9/H9 several isolated human bones were revealed within the filling of a modern cable duct. The surviving fragments are from a pelvis, probably from a female, and a pair of femurs belonging to a large robust male.

Early Bronze Feature and Artefacts (2300/1900 BC)

Pit 23 (Early Bronze Age III)

The pit is located in the western/north-western sector of sq. F14. It is elongated elliptical in shape, because its eastern third had been destroyed by a modern cable duct. The surviving part measures 0.85m east/west and 0.60m north/south. The bottom is flat, reached at a depth of 0.60m from the level of detection.

Two levels were distinguished within the filling of the pit. From the bottom up they are as follows:

The first level of the filling is composed of grey-black sandy soil of a medium high density. Yellowish clay spots of non-homogeneous structure occasionally appear. At a depth of 0.30m from the detection level a pile was revealed, consisting of two complete vessels and fragments of three others, and a large unprocessed stone of sandy texture (*fig. 33*). A fragment of a further ceramic vessel rim was lying below the stone. The fragments measure up to 0.30m in length and 0.15m in width. A complete vessel (a jug) was revealed 0.15m southwest of the stone. The jug was lying horizontally, slightly inclined to the south, with its rim facing south-east, and its base north-west. The handle and a part of the rim are missing. They had probably



Fig. 33. Akladi Cheiri. Overview of the upper layer of Early Bronze Age feature 23.



Fig. 34. Akladi Cheiri. Overview of the lower layer of Early Bronze Age feature 23.

been broken before depositing in the pit. Next to it to the west a ceramic spindle whorl, bi-conical in shape, was found. Some tubular bones from a small animal were revealed south-west and north-east of the jug. A ceramic object, red in colour and of an elongated arc-like shape and flat base, appears 0.20m north of the jug. The pile also contains small pieces of daub and two tiny stones.

The second level is composed of dark brown clay and homogeneous soil. Its thickness is 10 to 15cm. At a depth of 0.10m from the detection level a ceramic pile was found, consisting of three vessels and an unprocessed stone, medium in size (*fig. 34*). The pile is concentrated in the eastern sector of the pit. One of the vessels was located on top of the stone, the others were below the stone and had probably been broken by the fall of the stone. The third vessel is in the northern part of the pit, about 0.20m from the stone. Six tubular small animal bones were found in the south-western periphery of the pit.

The pit also contains a tool with a hole, made of bone, a stone pounder and a small piece of copper ore.

Discussion

The Akladi Cheiri material allows for partial reconstruction of the metallurgical activities in the area of the prehistoric site (Rehren et al. 2016). The copper ore extracted by the ancient miners had been transported to the processing site. There, it was broken into small pieces with stone pounders and grinders in order to extract the stone material and the iron ore, which was not smelted at that time. This is evidenced by the large amount of iron ore and the small malachite pieces revealed at the site. After enrichment, the copper ore was deposited in smelting installations, which had a collar shape. They were more than 20 or 25cm high but unfortunately, no evidence of their true size is available, and this prevents the estimation of the amount of ore needed for one furnace loading and the amount of metal produced. This smelting tradition was preserved in later periods. Pieces of similar installations have been found in the area of the Roman town of Nikopolis ad Istrum (Чолакова 2006). Charcoal was probably used as the fuel needed to achieve the necessary temperature. However, the function of the burnt ceramic sherds is unclear. Their features do not suggest that the vessels were used as crucibles. What is more plausible is that they were arranged in the smelting installation as a divider which regulated the firing process, accumulating heat, or for other purposes. As a result, the sherds are glazed with ore or copper particles stuck to their surface. Thus far, no evidence is available for the metal produced or any additional processing. The crucible and the two copper tools from the site show that the metal was re-smelted and cast in moulds. However, no finds relating to this production phase have yet been revealed.

The reasons for depositing various scraps of metal production in this feature remain unclear. The remains reflect most of the metallurgical processes and exclude the 'rubbish-pit interpretation'. A more likely explanation of their function is to view them as an expression of a well-developed ritual that accompanied the life of the ancient metallurgists.

The Akladi Cheiri material proves the presence of powerful ore extraction and a metallurgical site in the 5th mill. BC in that area. The presence of ore in the layers from the latter half of the 6th mill. BC supports the theorised pre-metallurgical phase needed for the accumulation of basic knowledge about the metallurgical raw materials. As a result, well-developed ore extraction emerged in the next period and the first copper tools were produced. Although no analyses of the ore pieces from Akladi Cheiri have yet been made in order to establish their origins, it is reasonable to believe that they came from the Medni Rid polymetallic deposits situated four or five kilometres west of the site. There are many possible reasons that the search for traces of these activities has not yet met with success. On the one hand, it could be explained as the preliminary phase of research. On the other hand, most of the traces of ore extraction in the 5th mill. BC had probably been destroyed during the exploitation of the deposits in antiquity by the Greek colony of *Apollonia Pontica*, in the Middle Ages, and more recently.

The analyses of copper tools from the Durankulak and Varna I cemeteries clearly show that a large part of the raw material for their production came from the Rosen ore field. This is suggestive of exchange contacts between territories, which were too remote from one another for the time.

These preliminary observations and conclusions demonstrate the need for continued research on the material from Akladi Cheiri in order to answer many questions about ore extraction, copper production and exchange routes in the southern Bulgarian Black Sea coast during the 5th mill. BC.

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Radka Zlateva-Uzunova

Results of the Technological, Typological and Raw Material Analysis of Chipped Stone Assemblages from Akladi Cheiri, Chernomorets

Keywords: raw material, chipped stones, Late Neolithic, Chalcolithic, Early Bronze Age

So far 4260 chipped stone artefacts from various prehistoric stages have been examined: Late Neolithic, Early and Late Chalcolithic and single tools related to the Early Bronze Age.

Late Neolithic

The artefacts related to the period of the Late Neolithic are the most numerous: 3262 pieces. The structure of the assemblage is dominated by the retouched tools (*table 1*), followed by the groups of flakes and blades. The cores, undeterminable fragments and natural pieces are considerably smaller in number.

Cores: 31 pieces (*table 2*). The group includes nine natural pieces displaying traces of direct attempts for chipping, although actions have not been exercised for pre-processing and shaping flake surfaces, striking platforms and other modifications.

Almost all of the artefacts in the group have been made on concretions.

The single-platform cores are presented by eight whole pieces and eight (mainly peak) fragments. The characteristics of the whole pieces have been analysed. Usually, concretions were used and only in two cases natural flakes, and in one case a natural piece. Almost all of the cores of this kind have been registered in final phase of exploitation as mainly the flakes were set apart. In two cases flakes and blades were detached, and only in one blades. The flake surfaces are mainly short and wide, being half-rounded and rounded (*fig. 1: 1*). In single cases, the knapping was done on the narrower side of the cores (*fig. 1: 3*). The shape of the cores is close to the conical or prismatic ones, traces of preliminary preparation are rare. The point parts are mostly natural, taken by an edge or they transform into a dot. In single cases, they are faceted (*fig. 1: 8*) or pre-processed by more than two blows. The striking platforms are also faceted almost without exception, only one has been prepared. Non-industrial surfaces have been also preserved entirely or partially along some of the sides and back. Preliminary preparation of the sides of the chipping platform (*fig. 1: 3*) or the back (*fig. 1: 6*) has been rarely observed. Only one artefact was pre-processed from the point.

Both double-platform cores in the collection were done on concretions; they are in the final phase of exploitation, flakes and blades were detached. Their shape is irregular and cone-like, and the chipping platforms are opposite in one of the cases (*fig. 1: 9*) and tangent in the other one. The points are natural. One of the cores has one of its sides displaying traces of pre-processing from the chipping platform.

There are two whole cores with changed orientation (*fig. 1: 4*). Concretions were employed for initial forms. The artefacts are in a final stage of exploitation for flakes. Their shape is irregular to irregular-oval and the chipping platforms tangent/detached; the point parts are faceted. Knapping was exercised on all of the fit surfaces as the blows were hit from edges between them.

The size of the whole artefacts is between 25 to 50mm in length, 10 to 50mm in width and 10 to

Technological groups	Late Neolithic		Early Chalcolithic		Late Chalcolithic		Early Bronze Age	
	n	~%	n	~%	n	~%	n	~%
Cores	31	1,0	13	1,3	-	-	-	-
Flakes and fragments of flakes	568	17,4	180	19,3	6	10,5	-	-
Flakes less than 15mm	595	18,3	165	17,6	7	12,3	-	-
Chips	258	8,0	35	3,7	-	-	-	-
Blades and fragments of blades	417	12,7	199	21,3	6	10,5	-	-
Bladelets	361	11,0	67	7,3	-	-	-	-
Retouched tools	760	23,2	208	22,3	37	65,0	8	100
Natural pieces	5	0,2	1	0,2	-	-	-	-
Undeterminable fragments	265	8,1	65	7,0	1	1,7	-	-
Others	2	0,1	-	-	-	-	-	-
Σ	3262	100	933	100	57	100	8	100
Σ	4260							

Table 1. Structure of the chipped stone assemblages from Chernomorets – Akladi.

Type	Late Neolithic		Early Chalcolithic	
	n	~%	n	~%
Single-platform cores	16	51,6	2	15,4
Double-platform cores	2	6,4	2	15,4
Cores with changed orientation	4	13,0	1	7,7
Concretions and fragments of concretions with traces of chipping	3	9,6	1	7,7
Natural pieces and fragments with traces of chipping	5	16,2	4	30,8
Natural flakes with traces of chipping	1	3,2	3	23,0
Σ	31	100	13	100

Table 2. Typology of the cores in the chipped stone assemblages from Chernomorets – Akladi.

Kinds of debitage	Late Neolithic		Early Chalcolithic		Late Chalcolithic	
	n	~%	n	~%	n	~%
Flakes and fragments of flakes	568	23,0	180	25,4	6	30,0
Flakes less than 15mm	595	24,2	165	23,3	7	35,0
Chips	258	10,5	35	4,9	-	-
Blades and fragments of blades	417	17,0	199	27,9	6	30,0
Bladelets	361	14,6	67	9,4	-	-
Undeterminable fragments	265	10,7	65	9,1	1	5,0
Σ	2464	100	711	100	20	100
Σ	3195					

Table 3. Differentiation of the debitage in the chipped stone assemblages from Chernomorets – Akladi.

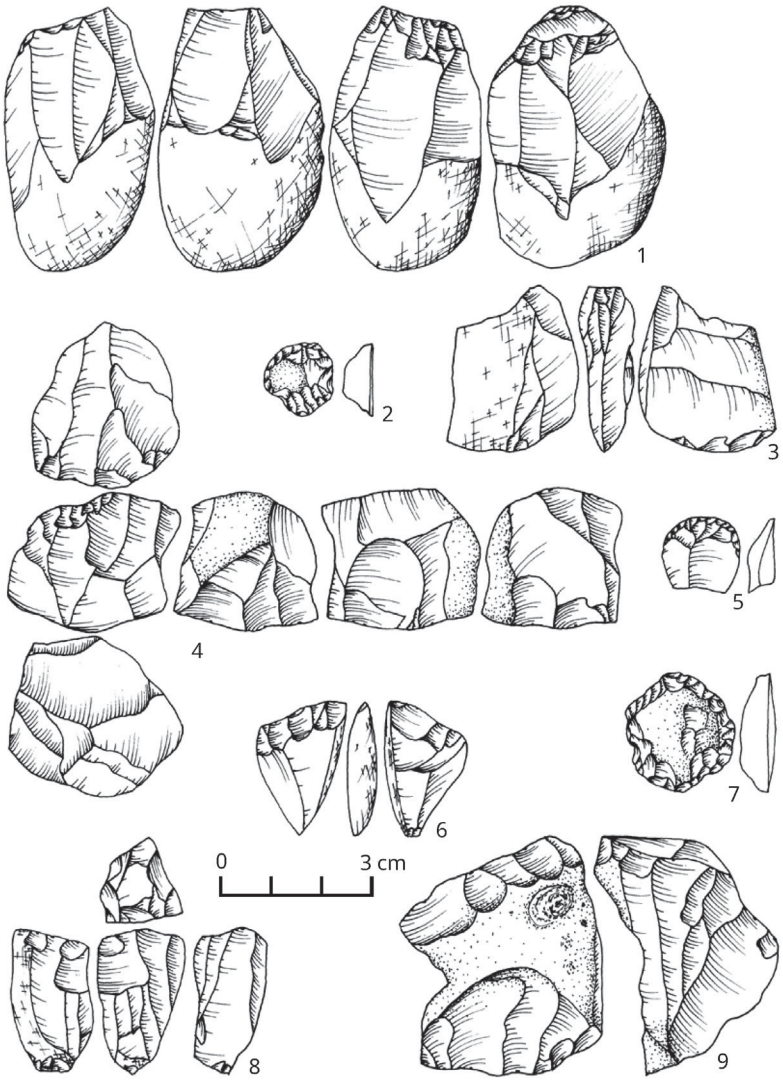

Fig. 1. Flint artefacts from Akladi Cheiri: 1, 3, 4, 6, 8, 9 cores; 2, 5, 7 end-scrapers. 1–9 Late Neolithic.

40mm in thickness as there is not any expressed grouping to be observed.

Flakes: 568 pieces (*table 3*). The whole artefacts are 461 in number. The group contains 62 distal and five proximal fragments. 77 flakes were used without any additional modification.

Semi-fabricates of a rectangular or trapezoidal shape prevail. There are also pieces of an irregular, triangular and oval shape although more rarely. The cross-sections are mostly multi-faceted. The triangular and trapezoidal examples are presented in similar values. Among the profiles, the straight and convex ones dominate, while the S-shaped ones are scantily represented. Butts have been preserved on 506 artefacts, mostly linear (*table 4*). Faceted and prepared pieces are also well represented. Almost without exception, their angles are between 90° and 100°.

Flakes from single-platform cores are dominant (*table 5*) followed by an almost similar number of artefacts obtained from cores in advanced stage of exploitation and from those with a partially preserved cortex and non-industrial surfaces situated differently to the morphology of the semi-fabricates. Flakes from cores with a changed orientation are represented in a significantly lesser degree. There are only few artefacts made from double-platform cores. Tablets are sporadic as well as one- and two-sided crests.

Only the whole artefacts among the debitage and the tools are presented with their length; the values of width and thickness concern the fragments as well. The measure of length and width is 10mm and of thickness 5mm.

The values of length of the flakes are grouped between 25 and 35mm (*table 6*). The pieces with

Kinds of bases	Late Neolithic				Early Chalcolithic			
	Blades		Flakes		Blades		Flakes	
	n	~%	n	~%	n	~%	n	~%
Prepared	97	53,3	101	20,0	30	47,7	38	25,8
Dihedral	31	17,1	90	17,7	18	28,6	23	15,6
Faceted	26	14,3	117	23,2	5	7,9	29	19,7
Natural	7	3,8	64	12,6	5	7,9	23	15,7
Linear	21	11,5	134	26,5	5	7,9	34	23,2
Σ	182	100	506	100	63	100	147	100

Table 4. Kinds of butts on blades and flakes in the chipped stone assemblages from Chernomorets – Akladi.

about 25 to 35mm rank second. The width between 15 to 25mm and 25 to 35mm prevails, and the thickness between 5 to 10mm.

Flakes smaller than 15mm: 595 pieces. Most of them with entirely or partially preserved natural surfaces suggesting that probably they belong to the stages of initial fracturing of the natural forms or preparation of the cores.

Chips: 258 pieces. These are leftovers from both the stages of secondary treatment (retouch) on the semi-fabricates and of precise preparation and repair of the cores.

Blades: 417 pieces. The group contains 113 distal, 122 mesial and 100 proximal fragments. The number of whole pieces is 82. On more than half of the artefacts, we can observe macroscopically distinguishable traces of use without any additional modification.

The lateral edges of most of the blades are divergent and straight. On third place are blades with convergent lateral edges. Irregular edges appear in less common cases. Concerning the cross-sections, the trapezoidal ones are the most common, followed by the triangular ones. Multifaceted and semi-elliptic cross-sections are restricted to single pieces. Among the profiles, the straight ones prevail, as the curved and S-like ones have almost the same number although they are significantly less.

The butts of 182 blades have been preserved and the ones prepared by a single blow dominate (*table 4*). Their angles are almost always within the limits of 90° to 100°. The analysis of the dorsal surfaces shows (*table 5*) that most of the semi-fabricates are from single-platform and seldom from double-platform cores mainly in an advanced stage of exploitation, detached by light hammer-stone, a mediator and more rarely pressure. Similarly to the group of flakes is the representation of one- and two-sided crests within the group.

The values of length of the blades are grouped mainly between 35 and 45mm (*table 7*) concerning the whole artefacts. Among them, the values of between 10 and 20mm for the width dominate, and 5 to 10mm for the thickness.

Bladelets: 361 pieces. Fragments dominate, displaying absent cortex on the dorsal surfaces, straight side edges, trapezoidal cross-sections and convex profiles obtained by means of pressure from single-platform cores in an advanced phase of exploitation.

Undeterminable fragments: 265 pieces of small undeterminable fragments mainly burnt.

Natural pieces: 5. The collection contains single concretions, fragments of them as well as natural fractions.

Others: 2 quartz geodes, one of them displaying traces of deliberate abrasion of the walls.

Retouched Tools

End-scrapers 294 pieces (*table 8*): The tools made on smaller flakes prevail, the end-scrapers on blades or fragments thereof are seldom (*fig. 3: 5*). The end-scrapers with arched fronts dominate in the group. In most cases only the front was processed

Negatives of the dorsal surfaces	Late Neolithic				Early Chalcolithic			
	Blades		Flakes		Blades		Flakes	
	n	~%	n	~%	n	~%	n	~%
From a single-platform core	251	60,3	129	22,9	155	78,0	46	25,5
From a single-platform core with a cortex dorsal surface	6	1,5	26	4,5	1	0,5	27	15,5
From a single-platform core with a ½ cortex on the dorsal surface	52	12,5	37	6,7	6	3,0	12	6,5
From a single-platform core with a lateral cortex	81	19,5	76	13,3	20	10,0	14	7,5
From a single-platform core with a cortex on the distal part	6	1,5	121	21,5	10	5,0	37	20,5
From a single-platform core with a cortex in the mezial part of the dorsal surface	2	0,4	8	1,4	2	1,0	9	5,0
From a double-platform core	8	1,9	14	2,4	2	1,0	3	1,6
From a double-platform core with a cortex dorsal surface	-	-	2	0,3	-	-	-	-
From a double-platform core with a ½ cortex on the dorsal surface	1	0,2	2	0,3	-	-	1	0,5
From a double-platform core with a cortex in the mezial part of the dorsal surface	1	0,2	8	1,4	-	-	-	-
From a double-platform core with a lateral cortex	1	0,2	7	1,2	3	1,5	2	1,0
From a core with a changed orientation	-	-	67	11,9	-	-	20	11,5
From a core with a changed orientation and a ½ cortex on the dorsal surface	-	-	5	0,8	-	-	-	-
From a core with a changed orientation and cortex on the distal part	-	-	6	1,0	-	-	-	-
From a core with a changed orientation and a lateral cortex	-	-	21	3,7	-	-	3	1,6
Tabletes	-	-	25	4,5	-	-	6	3,3
One-side crests	-	-	6	1,0	-	-	-	-
One-side crests with a cortex on the dorsal surface ½	3	0,7	1	0,1	-	-	-	-
One-side crests with a lateral cortex	2	0,4	-	-	-	-	-	-
Two-side crests with a cortex on the distal part	-	-	5	0,8	-	-	-	-
Two-side crests with a lateral cortex	3	0,7	2	0,3	-	-	-	-
Σ	417	100	568	100	199	100	180	100

Table 5. Characteristics of the dorsal surfaces of blades and flakes in the chipped stone assemblages from Chernomorets – Akladi.

Length in mm			Width in mm			Thickness in mm		
Class	**n**	**%**	**Class**	**n**	**%**	**Class**	**n**	**%**
15–25	97	21,0	15–25	284	50,0	1–5	73	12,8
25–35	230	49,9	25–35	256	45,0	5–10	430	75,7
35–45	131	28,5	35–45	28	5,0	10–15	65	11,5
45–55	3	0,6	45–55	-	-	15–20	-	-
Σ	461	100	Σ	568	100	Σ	568	100

Table 6. Metric parameters of flakes from the Late Neolithic from Chernomorets – Akladi.

Length in mm			Width in mm			Thickness in mm		
Class	**n**	**%**	**Class**	**n**	**%**	**Class**	**n**	**%**
25–35	18	21,9	<10	10	2,5	<5	188	45,0
35–45	51	62,2	10–20	400	95,7	5–10	229	55,0
45–55	10	12,2	20–30	7	1,8	>10	-	-
55–65	3	3,7	30–40	-	-	-	-	-
Σ	82	100	Σ	417	100	Σ	417	100

Table 7. Metric parameters of blades from the Late Neolithic from Chernomorets – Akladi.

Typological groups	Late Neolithic		Early Chalcolithic		Late Chalcolithic		Early Bronze Age	
	n	**~%**	**n**	**~%**	**n**	**~%**	**n**	**~%**
End-scraper	294	38,7	62	29,9	12	32,5	-	-
Combined tools	15	2,0	3	1,4	1	2,7	-	-
Perforators	7	1,0	11	5,2	1	2,7	-	-
Borers	6	0,7	1	0,4	-	-	-	-
Backed tools	21	2,7	1	0,4	-	-	-	-
Truncated tools	25	3,3	13	6,4	1	2,7	3	37,5
Segments	24	3,2	-	-	-	-	-	-
Trapeze	2	0,2	-	-	-	-	-	-
Triangles	3	0,3	-	-	-	-	-	-
Retouched blades	56	7,5	25	12,0	4	10,8	2	25,0
Notched tools	12	1,5	1	0,4	-	-	-	-
Splintered pieces	16	2,2	9	4,3	-	-	-	-
Side-scrapers	12	1,5	-	-	-	-	-	-
Retouched flakes	51	6,7	15	7,3	1	2,7	3	37,5
Undeterm. fragments of retouched tools	216	28,5	67	32,3	17	45,9	-	-
Σ	760	100	208	100	37	100	8	100

Table 8. Types of retouched artifacts in the chipped stone assemblages from Chernomorets – Akladi.

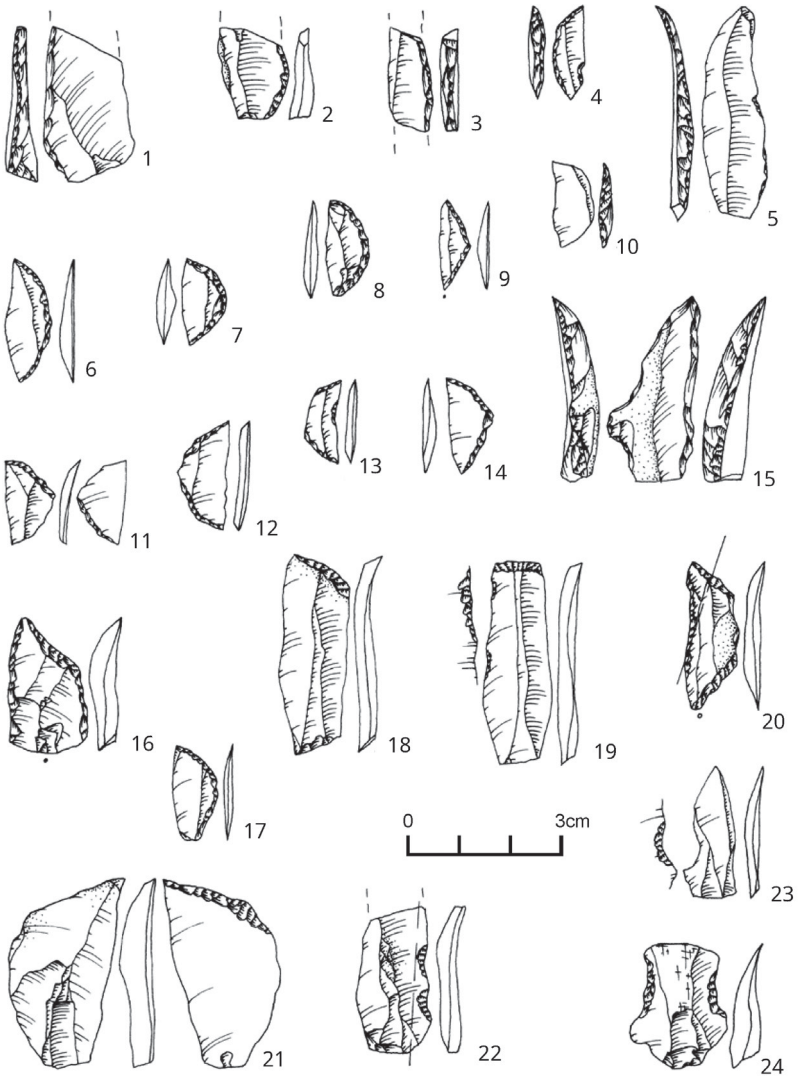

Fig. 2. Flint artefacts from Akladi Cheiri: 1–3, 5 backed tools; 4, 6–8, 10, 20 segments; 9, 11, 14 triangles; 13, 12 trapezes; 15 combined tool; 16–19, 21 truncations; 22–24 notched tools. 1–24 Late Neolithic.

(*fig. 1: 5; 3: 4*), there are also pieces with semi-steep retouch along one or both side edges of the dorsal (*fig. 3: 1, 3, 9*) or ventral surface (*fig. 3: 2*). The end-scrapers with straight (*fig. 3: 6, 7, 8, 10*) and oblique fronts (*fig. 3: 11*) are rare as well as the atypical ones (*fig. 3: 12*). Double end-scrapers rank second in the group after the pieces with arched fronts. We can observe also combinations of two arched (*fig. 3: 14*), oblique and straight (*fig. 3: 13*), oblique and arched (*fig. 3: 16*), and arched and straight front (*fig. 3: 17*). Round and half-round end-scrapers appear often in the collection (*fig. 1: 2, 7*).

Combined tools: 15 pieces. Almost all representatives of the group match the characteristics of end-scrapers with various kinds of fronts on the dorsal surfaces and bipolar splintered pieces – on the ventral ones (*fig. 3: 15*). We have registered a single burin on a blade with oblique truncation on the opposite edge (*fig. 3: 18*) and a tool with a gibbous shaped on one of the edges and a straight-backed opposite edge (*fig. 2: 15*).

Perforators: seven pieces. Perforators on fragments of blades and flakes processed by steep to semi-steep retouch which in most of the cases covers also the edges of the dorsal surfaces. Most of them are typical (*fig. 3: 20*), although atypical ones are also present (*fig. 3: 19*).

Borers: six pieces. They are repeating the characteristics of the previous group except that most of them have been made of blades (*fig. 3: 21, 23*).

Backed tools: 21 pieces. They are mainly fragmented, on blades and flakes. Most of the representatives of the group display a one-lateral straight backing (*fig. 2: 1, 3*), although some of them

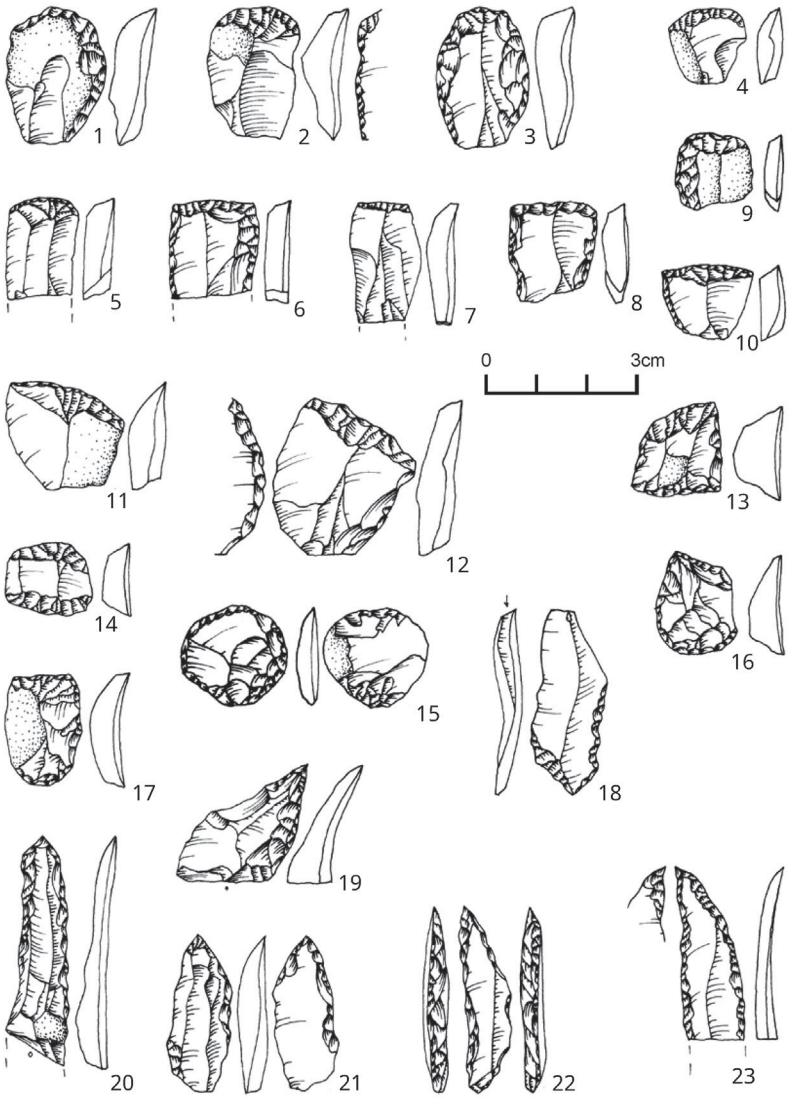

Fig. 3. Flint artefacts from Akladi Cheiri: 1–14, 16, 17 end-scrapers; 15, 18 combined tools; 19, 20 perforators; 21, 23 borers; 22 backed tool. 1–23 Late Neolithic.

bear a convex (*fig. 2: 2, 5*) as well as a combination of straight and convex backing (*fig. 3: 22*).

Truncated tools: 25 pieces. The artefacts with oblique truncation prevail as they have been made on blades as well as on flakes (*fig. 2: 16, 17, 21*). Straight truncations appear seldom (*fig. 2: 18*). Occasionally single pieces with double oblique truncations are also present with retouch on one or both side edges (*fig. 2: 19*).

Segments: 24 pieces. On fragments of flakes, blades and bladelets (*fig. 2: 4, 6, 7, 8, 10, 20*). They have been shaped by steep to semi-steep retouch in some cases being bi-serial.

Trapeze: two pieces. With two oblique truncations, on fragments of blades (*fig. 2: 12, 13*).

Triangles: three pieces. A type similar to the previous one except that the oblique sides meet to shape an angle (*fig. 2: 9, 14*). One of the pieces has the retouch on its oblique side applied along the dorsal and on the other along the ventral surface (*fig. 2: 11*).

Retouched blades: 56 pieces. Almost all of the elements of the group are fragmented as the ones with semi-steep retouch prevail. The retouch has been applied differently to the morphology of the semi-fabricates often, it is bi-lateral (*fig. 4: 3, 5*) and more rarely one-lateral (*fig. 4: 2*). Pieces with semi-steep/denticulated one (*fig. 4: 4*) and small retouch along the edge (*fig. 4: 1*) appear considerably seldom.

Notched tools: twelve pieces. On blades and flakes, although some on bladelets are also present. Most of the artefacts in the group have separate one-lateral and well-shaped notches

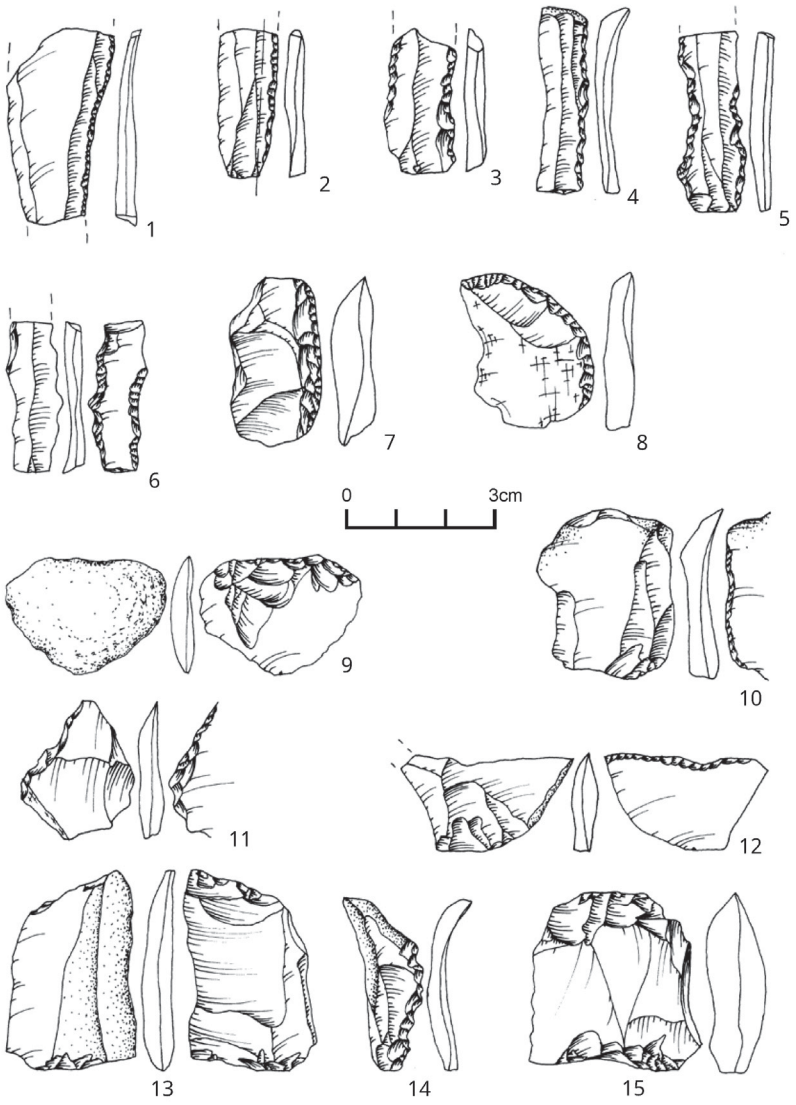

Fig. 4. Flint artefacts from Akladi Cheiri: 1–6 retouched blades; 7, 8 side-scrapers; 9, 13, 15 splintered pieces; 10–12, 14 retouched flakes.

(*fig. 2: 22*), others display a series of them along one of the edges (*fig. 2: 23*) or symmetrical ones on both opposite edges (*fig. 2: 24*).

Splintered pieces: 16 pieces. On flakes and fragments of flakes. Almost all of the artefacts in the group are to be determined as bi-polar (*fig. 4: 13, 15*). Few pieces are one- polar (*fig. 4: 9*).

Side-scrapers: twelve pieces. On flakes with steep to semi-steep one lateral retouch. The side-scrapers with a straight (*fig. 4: 7*) and a convex edge (*fig. 4: 8*) are presented in an almost similar number.

Retouched flakes: 51 pieces. Like the retouched blades, most of the artefacts display semi-steep retouch running differently to the morphology of the pieces. In most of the cases the retouch is one-lateral on the dorsal or the ventral surfaces (*fig. 4: 10*), and seldom bi-lateral. There are few flakes displaying one-lateral retouch on the dorsal and one-lateral on the ventral surface (*fig. 4: 11*) or applied across the distal parts (*fig. 4: 12*). The group of artefacts processed with semi-steep/notched retouch usually one-lateral is also small in number (*fig. 4: 14*).

Undeterminable fragments of retouched tools: 216 pieces. Small fragments are impossible to be related to a certain type.

Early Chalcolithic

Cores: 13 pieces. Most of the representatives of the group are natural forms without any pre-processing and attempts to a direct operation.

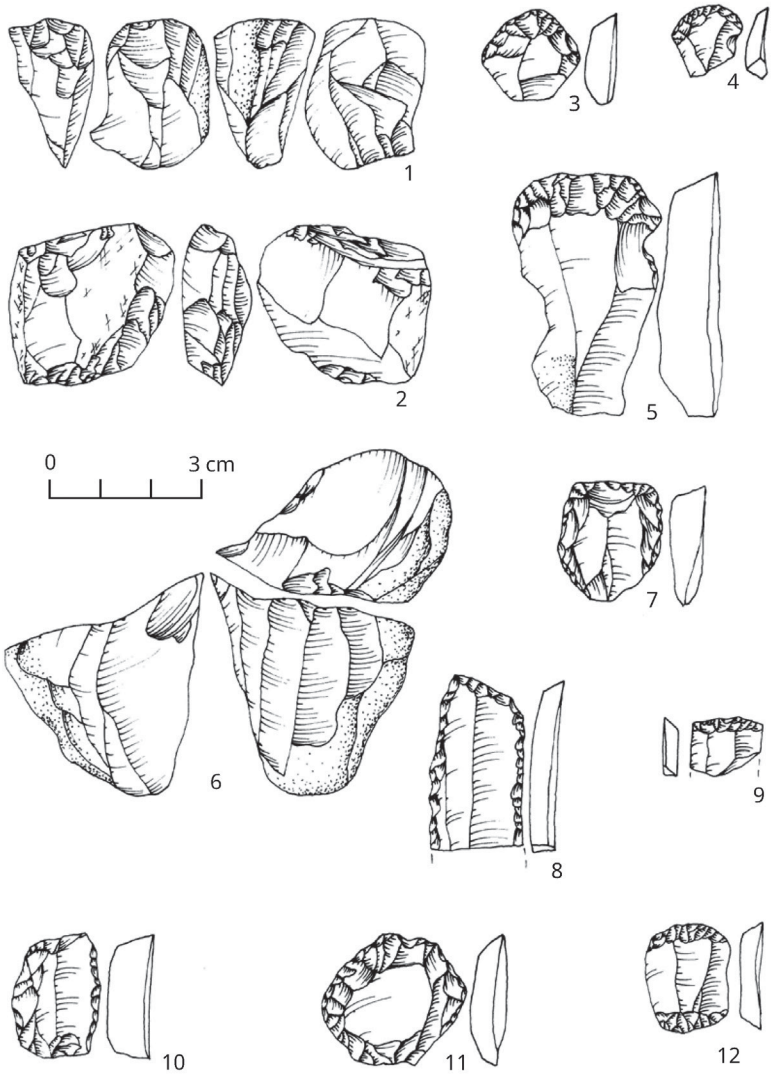

Fig. 5. Flint artefacts from Akladi Cheiri: 1, 2, 6 cores; 3, 4, 5, 7–12 end-scrapers. 1–12 Early Chalcolithic.

One only core of both single-platform pieces in the ensemble is whole (*fig. 5: 6*). It has been made on a concretion in an advanced phase of exploitation for blades. Its shape is conical with a flat semi-round chipping platform, faceted striking platform and preparation of one of the sides from the chipping platform.

There are two double-platform cores (*fig. 5: 1*) of a prismatic and conical shape, respectively, on concretions. They are registered in an advanced and final phase of exploitation for flakes, flakes and bladelets. The chipping platforms of both artefacts are semi-round, tangent in one case and opposite in the other.

The only core with a changed orientation has been made on a natural fragment; it is tile-like, with narrow tangent chipping platforms for obtaining flakes and blades (*fig. 5: 2*). The blows were hit by edge, the back is faceted. The artefact is in a final phase of exploitation.

Flakes: 180 pieces. Whole artefacts are 122 in number. There are 33 distal and 25 proximal fragments. 24 flakes bear traces of use without any additional modification.

Most of the flakes are of an oval, irregular or rectangular shape. The cross-sections are mostly multi-faceted. The trapezoidal and triangular ones are present in the same number; most rare are semi-elliptical ones. The arched and S-shaped profiles are dominant, straight profiles appear seldom. 147 artefacts have their butts preserved, mostly prepared by a single blow or linear (*table 4*) followed by the faceted ones. The angles are almost without exception within the limits of 90° to 100°.

Similarly to the collection from the Late Neolithic, the flakes from single-platform cores prevail

Length in mm			Width in mm			Thickness in mm		
Class	**n**	**%**	**Class**	**n**	**%**	**Class**	**n**	**%**
15–25	30	24,5	15–25	80	44,4	1–5	35	19,4
25–35	67	54,9	25–35	85	47,2	5–10	123	68,3
35–45	18	14,8	35–45	15	8,4	10–15	22	12,3
45–55	7	5,8	45–55	-	-	15–20	-	-
Σ	122	100	Σ	180	100	Σ	180	100

Table 9. Metric parameters of flakes from the Early Chalcolithic from Chernomorets – Akladi.

Length in mm			Width in mm			Thickness in mm		
Class	**n**	**%**	**Class**	**n**	**%**	**Class**	**n**	**%**
25–35	4	22,2	<10	2	1,0	<5	77	38,7
35–45	4	22,2	10–20	109	54,7	5–10	119	59,8
45–55	10	55,6	20–30	84	42,3	>10	3	1,5
55–65	-	-	30–40	4	2,0	-	-	-
Σ	18	100	Σ	199	100	Σ	199	100

Table 10. Metric parameters of blades from the Early Chalcolithic from Chernomorets – Akladi.

here as well (*table 5*). The difference comes with those with entirely or partially preserved cortex surfaces as they dominate the flakes obtained in an advanced phase of exploitation. Flakes from cores with a changed orientation, pieces from double-platform cores and tablets are represented significantly less.

The values of length of the flakes are grouped between 25 to 35mm (*table 9*). Second rank those about 15 to 25mm. Concerning the width flakes between 15 to 25mm and 25 to 35mm are present with similar values, and as regards the thickness 5 to 10mm.

Flakes under 15mm: 165 pieces. Flakes with entirely or partially preserved natural surfaces and those without it are represented in a similar number.

Chips: 35 pieces. Small, fine, without natural surfaces and probably relating to the stage of secondary modification and processing the semi-fabricates to retouched forms.

Blades: 199 pieces. The prevailing share of the semi-fabricates in the group is fragmented. There are 78 mesial, 58 distal and 45 proximal fragments. Only 18 of all are whole. 79 blades bear macroscopically distinguishable traces of use; one of them has been refracted from the ventral surface. Metrical parameters for length are mostly between 45–55mm (*table 10*), width around 10–20mm and thickness 5–10mm.

Most of the artefacts have their side edges straight. Twice as few are the divergent ones and three times the blades with convergent edges. There are only a few irregular ones . The trapezoidal sections dominate the transverse ones, followed by the triangular; the multi-faceted ones appear seldom. Most of the semi-fabricates have straight profiles. Other variants are significantly less frequent. The kind of butts of 63 proximal fragments and whole blades has been analysed. The prepared ones prevail, followed by dihedral (*table 4*). The linear, faceted and natural are represented in similar number. The angles at the butts seldom are more than 90° to 100°.

The blades in the group were obtained mostly from single-platform cores in advanced phase of exploitation well illustrated also by the data on the negatives of their dorsal surfaces (*table 5*) as the techniques of a soft hammer-stone and mediator were mainly employed.

Bladelets: 67 pieces. Mainly fragmented; whole pieces appear seldom. Similar to the previous collection, the elements in the group come almost without exception from single-platform cores in an advanced phase of exploitation. The difference lies in the fact that often the side edges of the bladelets from the Early Chalcolithic bear traces of use.

Natural forms: one piece. A fraction of raw material displaying attempts to employment it as a hammer-stone.

Undeterminable fragments: 65 pieces.

Retouched Tools

End-scrapers: 62 pieces. The tools on flakes prevail as those on blades or fragments of them appear significantly more rarely (*fig. 5: 8*). 44 are end-scrapers with arched fronts as on them, only the front was processed (*fig. 5: 5*). Micro end-scrapers with arched fronts, the double ones, with semi-steep retouch on one or both their side edges of the dorsal surface are present in single pieces (*fig. 5: 3, 4, 12, 7*). Atypical and half-round end-scrapers are rare as well (*fig. 5: 11*) and the ones with oblique fronts (*fig. 5: 8, 10*). Artefacts with straight fronts appear seldom (*fig. 5: 7, 9*) including those with processed edges of the dorsal surface.

Combined tools: three pieces. Similar to the ensemble from the Late Neolithic, the group contains artefacts combining the characteristics of end-scrapers and splintered pieces (*fig. 6: 1*).

Perforators: eleven pieces. Almost all of the tools in the group are on blades, a typical example is shown on fig. 6: 3. Still, there are a few of them on flakes as well as pieces whose point does not match the longitudinal axis of the semi-fabricates (*fig. 6: 2).* The retouches are steep to semi-steep.

Borers: one piece. Atypical, on a flake with steep/semi-steep retouch (*fig. 6: 4*).

Backed tools: one piece. On a blade with a one-lateral steep retouch on the dorsal surface shaping a straight edge.

Truncated tools: 13 pieces. Tools made on blades or flakes are presented in a similar number. The pieces with an oblique transverse truncation prevail (*fig. 6:* 6) although processing along the side edges with a semi-steep retouch also is to be observed (*fig. 6: 5*). Tools with straight truncation are less frequent (*fig. 6: 7*).

Retouched blades: 25 pieces. The use of semi-steep retouch prevails, but even more rarely there is a semi-steep/notched and in single cases small retouch along the edge (*fig. 6: 8*). Most of the artefacts have one or both of their edges of the dorsal surfaces processed (*fig. 6: 9, 11, 13*). Processing of edges on the ventral surfaces (*fig. 6: 10, 12*) as well as a combination of one-lateral retouch on both dorsal and ventral surfaces appear significantly less.

Notched tools: one piece. On a flake with a notch on the ventral surface shaped by semi-steep retouch (*fig. 6: 17*).

Splintered pieces: nine pieces. Made of flakes as the bi-polar ones dominate and here are only few one-polar examples. The secondary processing covers mostly the dorsal or both surfaces of the semi-fabricates (*fig. 6: 16).*

Retouched flakes: 15 pieces. Most of the representatives of the group were processed by semi-steep retouch almost without exception applied one-laterally to the dorsal surfaces (*fig. 6: 14*). In a few cases there is small retouch along the edge, artefacts with one of their side edges of the ventral surface processed, as well as pieces with retouch applied one-laterally in the distal part of the dorsal surface (*fig. 6: 15*).

Undeterminable fragments of retouched tools: 67 pieces.

Late Chalcolithic

Flakes: six pieces. Whole, trapezoidal in shape, of multi-faceted cross-sections, arched profiles, faceted butts with an angle of about around 100°, detached from single-platform cores in an advanced phase of exploitation. The length and width of all representatives in the group are about 30mm, and their thickness about 7mm.

Flakes under 15mm: seven pieces.

Blades: Six pieces. Mesial fragments, among them, dominating the ones with straight side edges, trapezoidal sections and straight profiles. All semi-fabricates in the group come from

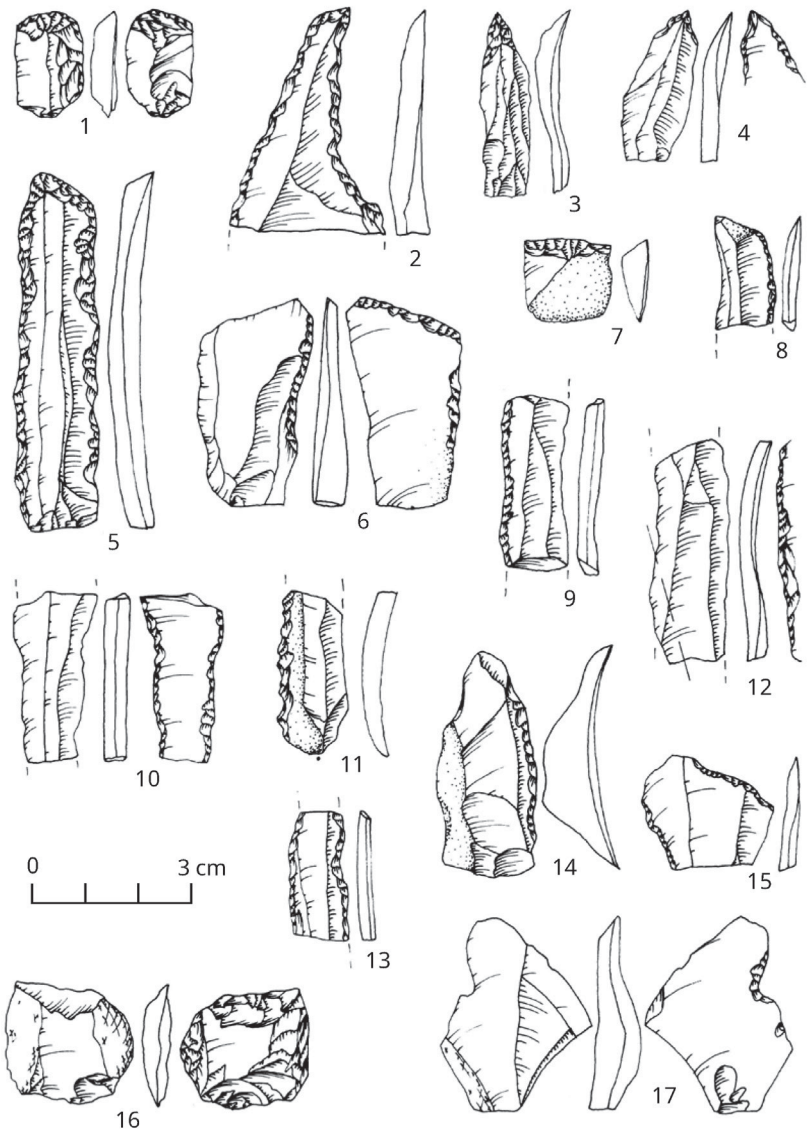

Fig. 6. Flint artefacts from Akladi Cheiri: 1 combined tool; 2, 3 perforators; 4 borers; 5–7 truncations; 8–13 retouched flakes; 16 splintered piece; 17 notched tools. 1–17 Early Chalcolithic.

single-platform cores in an advanced phase of exploitation, with macroscopically distinguishable traces of use.

Undeterminable fragments: one piece.

Retouched Shapes

End-scrapers: twelve pieces. The artefacts from blades and fragments of blades prevail. Most of the fronts are arched (*fig. 7: 2*), in certain cases retouch takes also the side edges of the dorsal (*fig. 7: 1, 10*) or ventral surfaces (*fig. 7: 5*). End-scrapers with a straight front, with a straight front and bi-lateral retouch on the dorsal surface (*fig. 7: 7*), with an oblique front (*fig. 8: 8*), and with an oblique front and bi-lateral retouch on the dorsal surface (*fig. 7: 7*) also appear with single representatives. There are two double end-scrapers as well. One of them bears two straight fronts (*fig. 7: 6*), and the other one a combination of an oblique and arched front (*fig. 7: 4*). A semi-steep bilateral retouch was applied to the dorsal surface of both artefacts.

Combined tools: one piece, one-lateral straight backing on a blade and an angle perforator (*fig. 8: 5*).

Perforators: one piece. Typical, with bilateral steep to semi-steep retouch on the dorsal surface (*fig. 8: 4*).

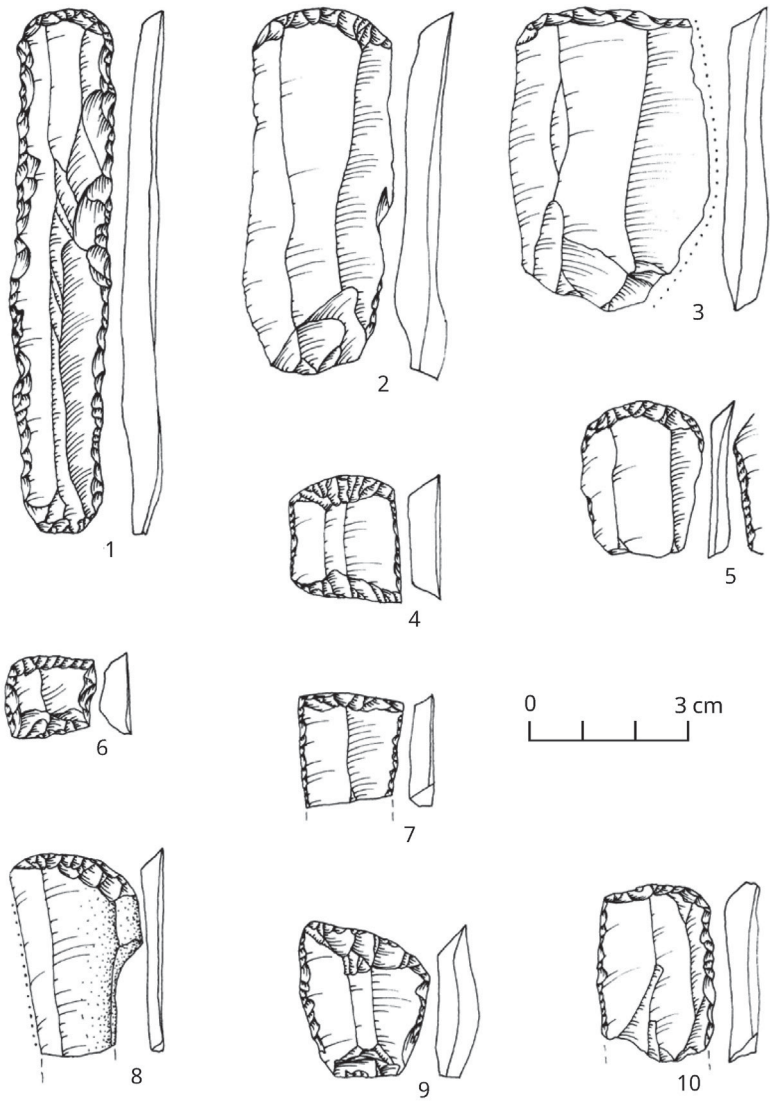

Fig. 7. Flint artefacts from Akladi Cheiri: 1–10 end-scrapers. 1–10 Late Chalcolithic.

Truncations: one piece. A distal fragment of a blade with oblique truncation.

Retouched blades: four pieces. With semi-steep retouch applied bi-laterally to the dorsal surfaces (*fig. 8: 1, 3*). Only one artefact has a one-lateral, unsystematic retouch (*fig. 8: 2*).

Retouched flakes: one piece. With one-lateral alternated semi-steep retouch.

Undeterminable fragments of retouched tools: 17 pieces.

Early Bronze Age

Truncations: three pieces. The blades have straight truncations. One of them has only the edge opposite the butt processed. In the second case, bilateral semi-steep/notched retouch was applied to the dorsal surface. The third representative in the group is a blade with straight truncation and alternated semi-steep/notched retouch along the side edges as we can observe clearly distinguishable polish as a result of work on one of them (*fig. 8: 9*).

Retouched blades: two pieces. A blade with one-lateral semi-steep retouch on the dorsal and partial flat one on the ventral surface (*fig. 8: 6*). The second artefact displays one-lateral semi-steep/notched alternated retouch (*fig. 7: 7*).

Retouched flakes: three pieces. Two of them are shaped by semi-steep/notched retouch. In one of the cases, it is bilateral on the dorsal surface (*fig. 8: 8*), and in the other one-lateral. The third artefact displays semi-steep retouch, one-lateral on the dorsal surface.

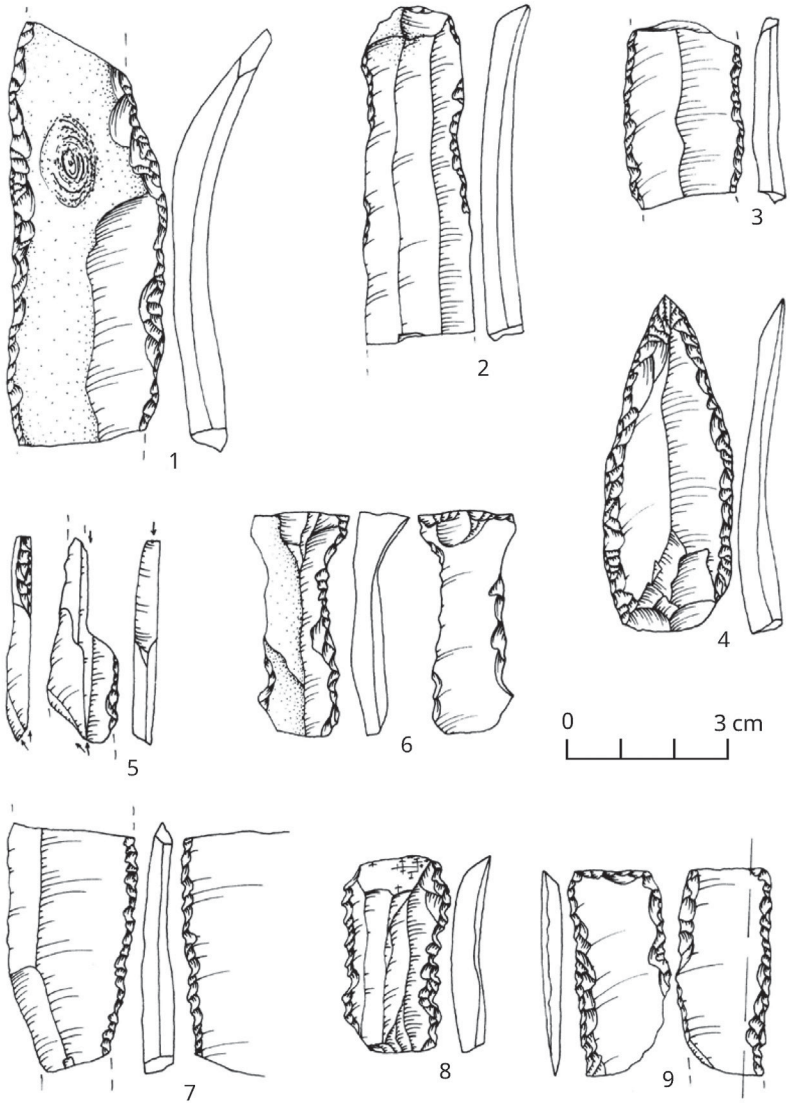

Fig. 8. Flint artefacts from Akladi Cheiri: 1–3 retouched blades; 4 perforators; 5 combined tool; 6–8 retouched blades; 9 truncations. 1–5 Late Chalcolithic; 6–9 Early Bronze Age.

Raw Materials

Nine varieties of flint (F) have been distinguished in the collection. On the grounds of the mineral composition of the most of them, their origin can be related to the regional pebble formations in general. Considering the traces observed on natural forms, we can assume that probably they come from secondary deposits in the region of the stony beaches in the vicinity of the site and they have been the subject of gathering. There is also quartz (Q, *fig. 9: 1*), opalised wood (SW, *fig. 9: 2*), opal/chalcedony (OCh) and malachite (M) present.

BG.Ac.F1: whitish-yellow to beige, with white tiny inclusions and spots (*fig. 9: 3*), unbundled and evenly distributed. Fine-grained, micro-layered, slightly transparent, with a lightly shining smooth surface, a thin whitish smooth cortex and good technological qualities. Rare unbundled quartz/chalcedony veins and micro-fissures are to be observed.

BG.Ac.F2: brownish-red with intensive white to beige inclusions and spots (*fig. 9: 5*). Matt slightly transparent fracture with good technological potential. Colo-morphous to fine-grained chalcedony/quartz/opal mass with rare chalcedony formations and veins.

Bg.Ac.F3: with parts in whitish-grey and white tinge. White inclusions and spots unevenly distributed within the rock mass and forming clusters in the next-to-cortex parts. Micro-layered, from slightly to highly transparent, with a lightly shining smooth surface to be observed as well as a thin white smooth cortex and good technological

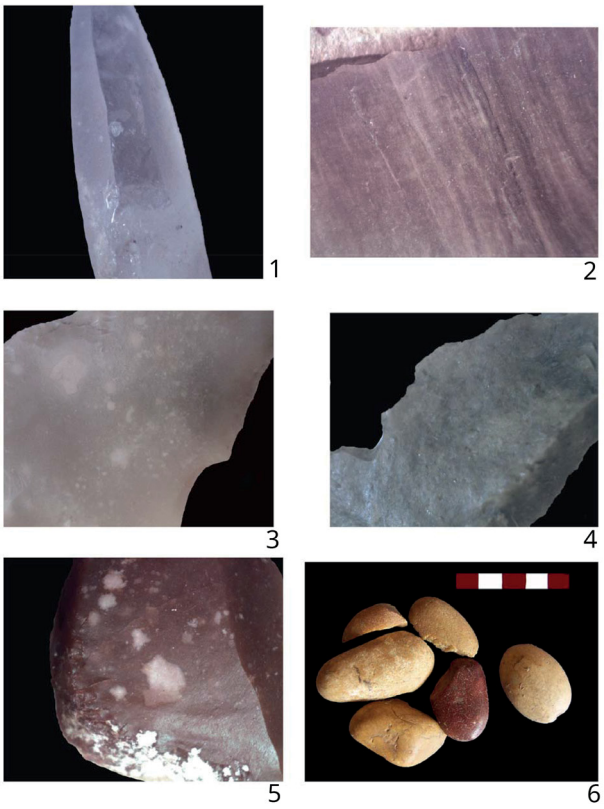

Fig. 9. 1 Quartz geode, Akladi Cheiri; 2 opalised wood, Akladi Cheiri; 3 variety BG.Ac.F1, Akladi Cheiri; 4 variety BG.Ac.F4, Akladi Cheiri; 5 variety BG.Ac.F2, Akladi Cheiri; 6 natural pieces, Akladi Cheiri.

qualities. Chalcedony veins and fissures are seldom to detect.

Bg.Ac.F4: brown ochre with spots of a lighter tinge (*fig. 9: 4*). Fine-grained, micro-layered, with an opaque smooth to slightly rough fracture and good technological qualities. No clues to cortex, infractions or initial shapes.

Bg.Ac.F5: light beige, fine-grained, with a smooth slightly matt surface. Opaque, with rare whitish spots and tiny to medium quartz grains. No clues to infractions and cortex, excellent technological qualities.

Bg.Ac.F6: brown to whitish dark yellow, fine-grained, micro-layered, from slightly to highly transparent, with a slightly shining smooth surface and very rare white spots, good technological qualities. With rare chalcedony inclusions.

Bg.Ac.F7: deep dark grey to black with rare unbundled lighter grey inclusions, fine-grained, micro-layered, slightly transparent, with a smooth matt fracture. No clues to infractions. With a whitish rough comparatively thin cortex, excellent technological qualities.

Bg.Ac.F8: parties of white, rose, grey and reddish tinge in a band-like arrangement. Matt slightly rough opaque fracture. Thin brown weathering cortex and rare quartz formations of irregular shape. Medium technological potential.

Bg.Ac.F9: white to cream coloured, particular parts display varying degrees of transparency. The fracture is smooth and matt. The inclusions are of organogenic and mineral origins, spots of whitish and light grey different colours, unbundled. Good technological qualities.

Bg.Ac.MI: deep green colour, with a matt shine on the surface, opaque, of an unclear zonal texture. The sample is characterised as a coating formed by the alternation of copper ore/malachite.

Bg.Ac.Och1: deep brown, micro-layered, with a highly transparent smooth surface with oily shine and rare whitish inclusions of irregular shape. No clues to infractions and cortex. Excellent technological qualities. It can be determined as opal/chalcedony.

Bg.Ac.Sw1: brown in colour with grey and beige spots, opaque, with a matt rough fracture; a thin yellowish weathering cortex to be observed. The sample is defined as wood replaced by opal/chalcedony mass.

Bg.Ac.Q1: quartz crystal covered with a coating of iron oxide. Crystal walls preserved. Whitish with a slight yellowish tinge, highly transparent, rough and shiny fracture.

Artefacts made of variety F4 dominate in the collection from the Late Neolithic (*table 11*). Second, with similar values rank the pieces made of raw material F6. Well represented are also the artefacts of variety F1. The rest of the raw materials have been employed more rarely. The variety F1 was used for the most cores in the assemblage, while it was F4 for the group of flakes. For the flakes, raw materials F6, 5, 1, 2 and 3 were also employed in similar amounts. The prevailing number of blades was made of varieties F6 and 1. For the typological tools, they preferred F1, 6 and 4.

Varieties F1 and F6 (*table 12*) prevail in the group of raw materials from the early Chalcolithic. The artefacts made of raw material F4 are significantly less in number unlike the ensemble from

Raw material No.	Cores	Flakes	Blades and bladelets	Retouched tools	Others	Undeter-minable	Σ	%
BG.Ac.F1	10	175	205	209	2	4	605	18,6
BG.Ac.F2	1	119	38	35	-	3	196	6,0
BG.Ac.F3	1	115	86	45	1	12	260	8,0
BG.Ac.F4	6	458	96	130	-	39	729	22,3
BG.Ac.F5	2	164	47	85	-	6	304	9,3
BG.Ac.F6	7	266	216	176	-	41	706	21,6
BG.Ac.F7	1	31	29	15	-	1	77	2,3
BG.Ac.F8	2	62	53	24	-	9	150	4,5
BG.Ac.F9	-	18	7	4	-	2	31	1,0
BG.Ac. Och1	-	7	-	7	-	-	14	0,5
BG.Ac. SW1	-	6	1	1	-	4	12	0,4
BG.Ac.M1	-	-	-	-	2	-	2	0,1
BG.Ac.Q1	-	-	-	-	2	-	2	0,1
Undetermin.	1	-	-	29	-	144	174	5,3
Σ	31	1421	778	760	7	265	3262	100

Table 11. Quantitative distribution of raw materials varieties in technological groups in the chipped stone assemblage from the Late Neolithic, Chernomorets – Akladi.

the Late Neolithic. All three kinds of raw materials mentioned above were used almost equally for the cores. The groups of flakes, blades and bladelets, as well as the retouched tools, were made mainly of variety F1.

All flakes in the collection from the Late Chalcolithic were made of variety F4 (*table 13*) while most of the representatives of blades and retouched tools of type F1. We have to note also the reduction of the variety of raw materials in the assemblage.

Most of the retouched tools relating to the Early Bronze Age were made of variety F1. Varieties F5 and F7 are represented by one artefact each.

The group of retouched tools dominates in the assemblage from the Late Neolithic presented above. The high percentage of some elements of the debitage also strikes – the flakes, flakes under 15mm and chips. The technological chain was oriented mainly to the exploitation of single-platform cores shaped from concretions 150mm in diameter and knapping of flakes comparatively small in size. The metric parameters of the natural forms and the cores in the collection do not allow the production of series of semi-fabricates of a more significant size. The observations presented above and partly the techniques employed – mediator or pressure – largely predetermine the characteristics of the semi-fabricates and hence the rest of the assemblage, i.e. the observed standardisation of the size of flakes and retouched tools made of them. Although a few, natural forms are represented in the collection, small concretions without attempts to exploitation or processing (*fig. 1: 6*). They bear traces of intensive smoothing as a result of transport on water or a long stay in an aquatic environment. Considering the traces observed on the natural forms and also the similar features found on the prevailing share of raw materials types we can assume that probably they come from the stony beaches in the vicinity of the site and most of them have been the subject of gathering.

Within the typological structure of the assemblage, the variants of end-scrapers prevail. The presence of undeterminable fragments of

Raw material No.	Cores	Flakes	Blades and bladelets	Retouched tools	Others	Undeterminable	Σ	%
BG.Ac.F1	4	104	101	71	1	9	290	31,0
BG.Ac.F2	-	20	11	7	-	-	38	4,0
BG.Ac.F3	1	12	17	13	-	3	46	5,0
BG.Ac.F4	3	91	23	11	-	3	131	14,0
BG.Ac.F5	1	43	27	22	-	3	96	10,3
BG.Ac.F6	4	89	73	41	-	5	212	22,8
BG.Ac.F7	-	12	4	14	-	-	30	3,3
BG.Ac.F8	-	6	9	6	-	-	21	2,2
BG.Ac.F9	-	2	-	2	-	-	4	0,4
BG.Ac. OCh1	-	1	1	2	-	-	4	0,4
BG.Ac. SW1	-	-	-	2	-	-	2	0,2
Undetermin.	-	-	-	17	-	42	59	6,4
Σ	13	380	266	208	1	65	933	100
Σ	933							

Table 12. Quantitative distribution of raw materials in technological groups in the chipped stone assemblage from the Early Chalcolithic, Chernomorets – Akladi.

retouched forms is also significant in percentage terms. All the rest of the types are less represented. The retouched blades and flakes make up the second group. The truncated and backed tools and the segments compose the third group presented with similar values. Side-scrapers, splintered pieces, combined and notched tools, perforators, borers, trapezes and triangles are also presented. The presence of microliths appears to be one of the characteristics of the collection. Until recently the discovery of similar types in assemblages from the Late Prehistory was associated with some retarding Palaeolithic or Mesolithic techniques and technological traditions. Nevertheless, the introduction into scientific circulation of more collections coming from new as well as from some earlier terrain archaeological research in various regions in Bulgaria reveals that the typological composition of the assemblages from the Late Prehistory is not limited to such types as end-scrapers, retouched blades and flakes, and that varieties of secondary treatment can be observed.

The prevailing share of the elements in the assemblage has been registered within pits. The amount of artefacts discovered outside them is minor. The high degree of fragmentation even in the group of cores, the intensive traces of use observed on the debitage and the retouched tools, and the significant percentage of tiny flakes and chips can be interpreted as indication that in the pits the waste from the production process and artefacts were thrown away due to damage or failure from later work was deposited. We should not exclude the possibility that some of the artefacts to have been intentionally fragmented and subjected to a thermal impact prior to disposal. The high degree of fragmentation and the numerous burnt undeterminable fragments support this hypothesis.

At this stage of research, we can say that some features of the material here discussed are similar to the ones in the Neolithic collections from the same region still in the process of work – Chernomorets – Garmitsa and Budzhaka. Analogies are found among the materials from Usoe (Gatsov 1987; 1990), Kapitan Dimitrievo (Гацов 1999), Durankulak (Sirakov 2002), Drama-Gerena (Lichardus et al. 2000), and Lyubimets (Анастасова 2012). Up to now, most of the assemblages of similar

Raw material No.	Flakes	Blades and bladelets	Retouched tools	Others	Σ	%
BG.Ac.F1	-	5	13	-	18	31,5
BG.Ac.F2	-	-	2	-	2	3,5
BG.Ac.F3	-	-	1	-	1	1,8
BG.Ac.F4	13	-	-	-	13	22,8
BG.Ac.F5	-	1	2	-	3	5,2
BG.Ac.F6	-	-	1	-	1	1,8
BG.Ac.F7	-	-	-	1	1	1,8
BG.Ac.F8	-	-	1	-	1	1,8
Undetermin.	-	-	17	-	17	29,8
Σ	13	6	37	1	57	100

Table 13. Quantitative distribution of raw materials in technological groups in the chipped stone assemblage from the Late Chalcolithic, Chernomorets – Akladi.

characteristics are interpreted as materials with regional peculiarities (Анастасова 2012). However, the further research and release of new data in academic literature suggest that contours are outline of a new aspect of the Neolithic chipped stone collections unknown so far covering a broader geographical spread and chronological position.

The material from the Early Chalcolithic is rather similar to the one from the previous age. The retouched tools dominate, followed by the blades and flakes. The representatives of the rest of the groups are sporadic. Some of the major features and metric parameters of most of the debitage are analogical to the previous collection (*table 4, 5, 6, 9*) as we have to note also the variations in the group of the blades (*table 7, 10*) and the retouched tools made of them. We can observe a reduction of the typological (*table 8*) and raw material diversity (*table 12*).

The chipped stone assemblages from the Early Chalcolithic and their raw material base subjected to specialised studies are still few (Gatsov 1997; Kurchatov/Stanimirova 1997; Златева-Узунова/Митева 2009; Сиракова/Златева-Узунова 2012). The assemblage here presented finds partly parallels only with Dervishov Odzhak (Gatsov 1997) although possibly we can look for similarities at sites from the Early Chalcolithic as Chavdarova Cheshma, Dushubaka, Shihanov Bryag and so on, if and when their assemblages are explored (Leshtakov 1997).

The artefacts from both Late Chalcolithic and Bronze Age are small in number and series of diagnostic forms are missing.

With the gradual enrichment of the evidence base concerning the prehistoric chipped stone assemblages, it becomes clear that there are many unknown and still unexplored aspects of this industry. For many regions and periods, we have not yet enough data to carry out correct comparative analyses. This is the case with the southern Bulgarian Black Sea coast and with the chipped stone implements in particular.

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The Chalcolithic Copper Smelting at Akladi Cheiri

Keywords: Bulgaria, chalcolithic, copper, ore, smelting, crucibles, scientific analyses, technology and provenance

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Introduction

The excavations in Akladi Cheiri produced a number of green and brown metal-rich mineral fragments scattered across the site and in layers dated from the Late Neolithic to the Late Chalcolithic periods. One feature in particular, the Late Chalcolithic Pit 28 also yielded a large number of slagged ceramic fragments, indicating metallurgical activity being conducted on the site. This chapter reports the results of the analytical study of this material and offers a tentative reconstruction of the metallurgy and the provenance of the ore fragments.

The Material

Ore Finds

Fragments of copper- and iron-rich mineral aggregates were found in most features; for convenience they are here collectively referred to as ore. Most likely, they are discarded material, representing pieces deemed not good enough for further processing. The analysed fragments were selected to cover the spectrum from dark rust brown to bright green, with some yellow to dark steel blue parts. Their size ranges from pea to walnut-size, with green ores tending to be of smaller size than brown ores. The total amount of this material is estimated to be several kilograms; most of this was concentrated in Pit 28 (see Leshtakov et al., this volume, 89–120).

Twelve samples were selected in order to cover the range of features and appearance (brown to green; *fig. 1*). Five samples were from Pit 28 and are directly associated with the slagged ceramic (see below): three ‘brown’ samples ACH 116a, 116b and one without number, and two ‘green’ samples ACH 117 and 166. Three more samples are from the ‘swimming pool’ site: ACH 67 and 69 (‘green’) and 70 (‘brown’). Four green samples were selected from other sites across Akladi Cheiri (ACH 98, 109, 160 and 164). No analyses of these samples had been published previously (but see Kunze/Pernicka, this volume, 391–418), and their identification as ‘ore’ was based on visual inspection and their suspected relation to the slagged ceramics from the site. Strictly speaking, the term ‘ore’ refers only to material from which metal can be beneficially extracted, and should not be used for

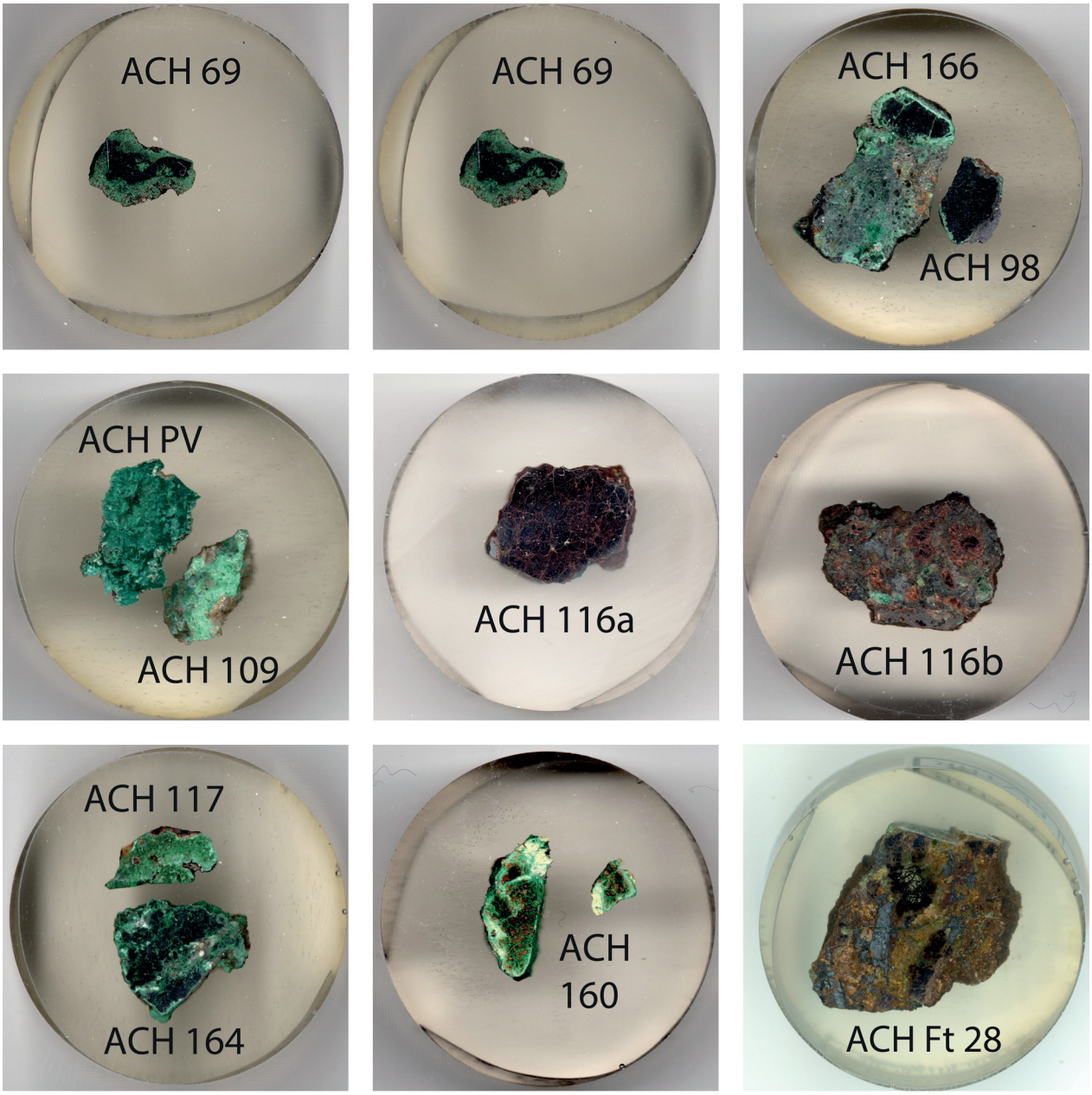

Fig. 1. Selection of ore fragments from Akladi Cheiri, mounted for microscopic investigation. Diameter of each block is 3cm.

minerals that were collected for non-metallurgical purposes such as use as pigment or for the production of beads and other jewellery. This distinction is particularly relevant for those fragments which have been excavated from Late Neolithic contexts, and thus pre-date known metal smelting activity in this area. However, for convenience we will continue to refer to these fragments as 'ore', without implying that in every case they were brought to the site with the intention to be smelted to extract metal.

Slagged ceramic

Pit 28, dated broadly to the middle of the 2nd half of the 5th mill. BC, produced several hundred fragments of slagged ceramic; it is the only feature at this site where such material had been found. Quite often, the slagging covers old breaks, but is predominantly found on the concave side of the sherds. Significantly, the sherds represent almost exclusively broken domestic pottery; only three pieces of a single purpose-made crucible were found.

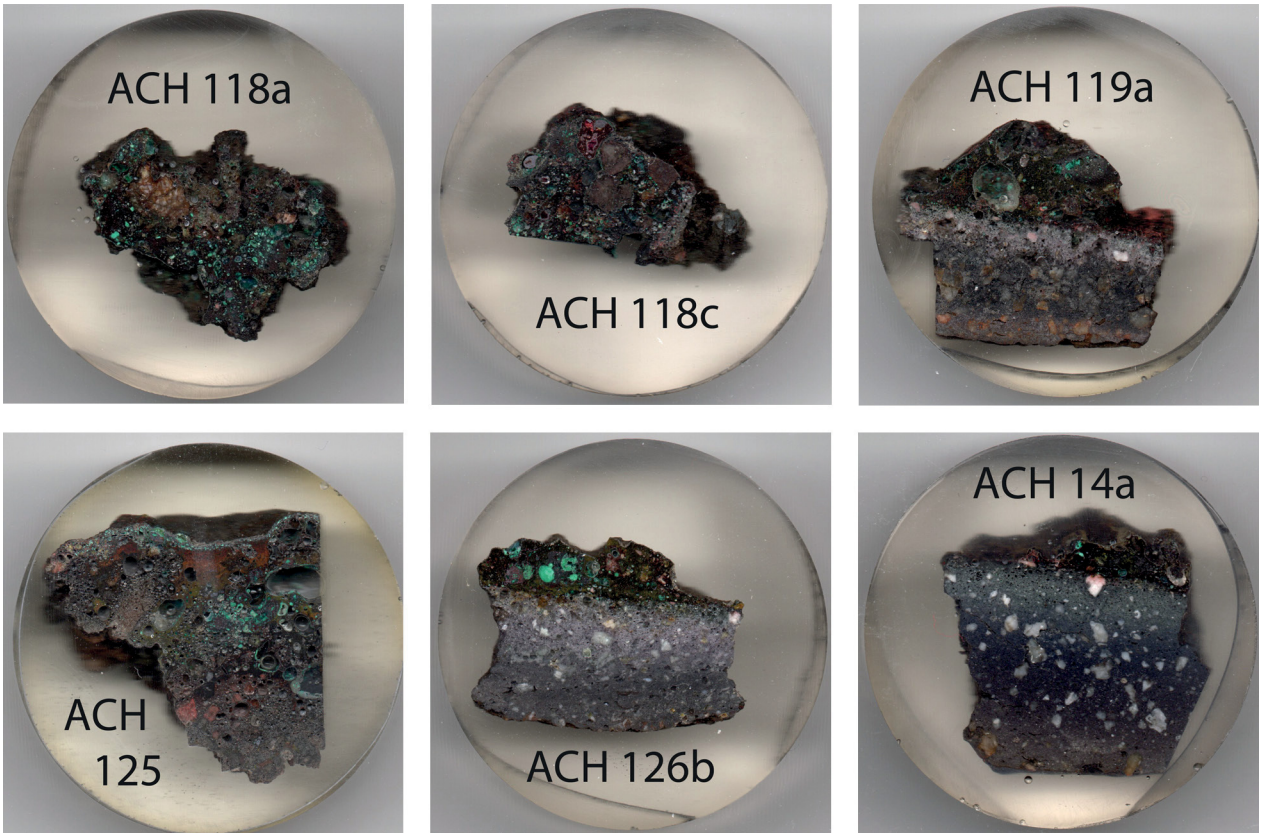

Fig. 2. Selection of slagged ceramic fragments from Akladi Cheiri, mounted for microscopic investigation. Diameter of each block is 3cm.

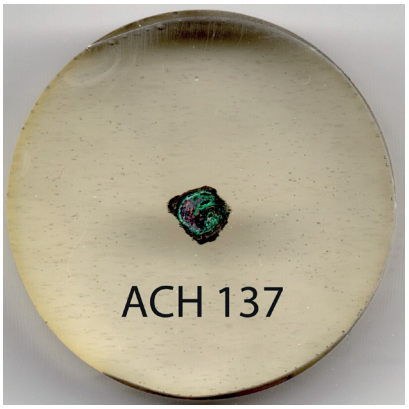

Fig. 3. Metal fragment from Akladi Cheiri, mounted for microscopic investigation. Diameter of block is 3cm.

Fourteen pieces were selected for their well-developed slag content and are as such representing the more heavily slagged fraction of the entire assemblage (*fig. 2*). They cover the observed range of appearance spanning from slag layers in a clear sharp contact with ceramic, to very mangled and fused masses of slag and heavily vitrified ceramic. A few of these had been analysed previously in a pilot study (Rehren et al. 2016), which confirmed that the slag formed during smelting of a copper ore containing some sulphur, but probably not a sulphidic ore. One of the samples contained elevated concentrations of molybdenum oxide, reaching several weight percent in the magnetite crystals within the slag.

Only three metal objects were found at the site, namely one small metallic bead or lump a few millimetres in diameter, from a Late Neolithic context (ACH 137; *fig. 3*), and two awls, one of which as a surface find.

Question and Context

The metallurgical assemblage described above is unique in its extent and well-documented Late Chalcolithic context, and was analysed in order to characterise this very early metallurgy as much as possible. Key questions to be addressed include whether the green and brown mineral lumps can be linked to the extraction of metal and therefore rightly called ‘ore’, as opposed to green (gem) stones used for bead or pigment making; whether the slagged ceramic can be confirmed as evidence

for the regular smelting of copper metal as indicated by the pilot study; and, if both questions are answered positive, whether the two materials can be linked into one production sequence beyond reasonable doubt and how much we can say about details of this smelting technology. Finally, we will explore to which extent the ore from Akladi Cheiri can be linked to the copper-bearing mountain ridge ('Medni Rid') in the hinterland of the smelting site, and the wider Chalcolithic metallurgy in the eastern Balkans (see Kunze/Pernicka, this volume, 391–418).

To do this, we first characterise the ore samples and present the results of optical microscopy and SEM-EDS analyses. We also briefly characterise the composition of the ceramic in order to test whether it has contributed significantly to the slag formation, and how the thermal impact of the process has affected it. This then is complemented by several lead isotope analyses, as part of a broader exploration of resource exploitation in eastern Bulgaria (see chapters on mining and metallurgy in this volume).

The selected pieces were first cut to expose their inner structure as well as any outer layers of corrosion or weathering, then cast in discs of clear cold-setting resin with 3cm diameter and prepared as polished blocks using a sequence of increasingly finer abrasives and polishing powders, down to 1µm diamond paste. Following documentation using optical microscopy in reflected plain polarised (PPL) and cross-polarised light (XPL) the discs were carbon-coated in preparation for Scanning Electron Microscopy and Energy-Dispersive Spectrometry (SEM-EDS). A selection of slag and ore samples were also analysed by neutron activation for bulk major and trace element concentrations and by mass spectrometry for lead isotope ratios to determine their provenance (see Kunze/Pernicka, this volume, 391–418).[1]

Results

The Ore

All ore samples, whether green or brown, form a continuum of originally sulphidic ore which is now almost completely weathered. They are now dominated by secondary minerals, typically green malachite or brown goethite or other iron hydroxides, with characteristic relict or 'ghost' textures and some physical remains of the original pyrite and chalcopyrite, and minor amounts of gangue minerals such as haematite and quartz. The range of samples spans from pure green fragments to pure dark brown pieces, with intermediate mixtures in between (see *fig. 1*). Several pieces have a green outer crust which formed only after they were broken into their current shape; therefore, this crust is considered the result of post-depositional weathering rather than reflecting the original appearance of these pieces at the time of the settlement at Akladi Cheiri.

A few fragments have substantial amounts of chalcopyrite preserved (*fig. 4a*). Considering that they have been buried in an aggressive environment for more than five millennia, this raises the question whether these were even more solid pieces of chalcopyrite at the time of deposition, and have only since then weathered to the extent visible now. Significantly, some 'green' ore fragments have parts of typical 'brown' ore attached to them (*fig. 4b),* showing how the green ore formed veins or crusts of almost pure malachite directly attached to the brown ore (*fig. 4c*); in other areas green and brown secondary minerals are tightly intergrown in the same piece (*fig. 4d*). It is not possible to say whether the completely weathered brown ore fragments were originally pyrite or chalcopyrite, and often both may have been present; quite frequently the brown ore has very little if any green minerals in its body, suggesting originally dominating pyritic composition. Some of the green ore fragments have large amounts of pure copper sulphide minerals in their core, such as chalcocite and covellite, surrounded only by a small rim of green copper minerals (ACH 69, 98 and 166; *fig. 4e*). Here, the rim-like presence of the malachite rind strongly indicates that this mineral only formed after the original sulphide-rich ore

1 Since the microscopic and the chemical analyses were initially separate undertakings and some sample bags contained more than one piece, it is not certain that exactly the same material was analysed even where they share the same sample number.

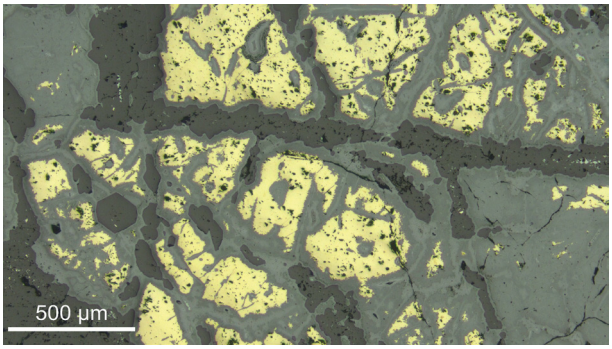

Fig. 4a. Brown ore, with weathered chalcopyrite (yellow) in a matrix of iron hydroxides (mid-grey) and quartz (dark grey). Sample ACH 70, reflected light.

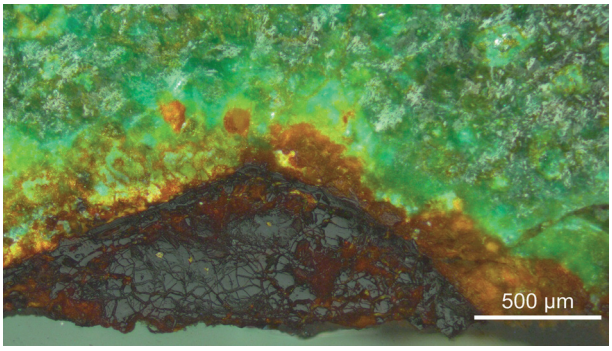

Fig. 4b. Brown iron hydroxides (bottom) surrounded by green malachite. Sample ACH 117, reflected light, crossed polarising filters.

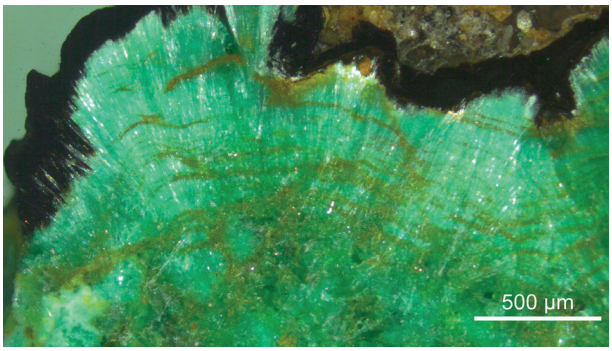

Fig. 4c. Pure malachite with typical texture of sub-parallel needles in concentric layers. Sample ACH 117, reflected light, crossed polarising filters.

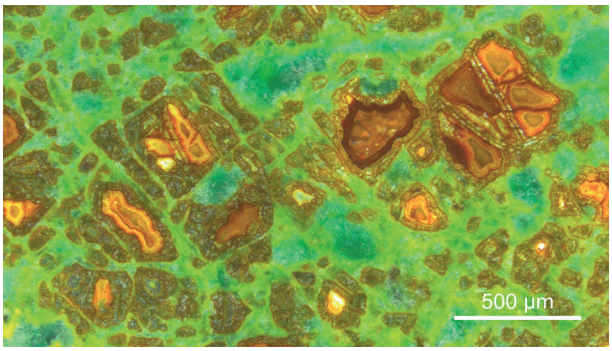

Fig. 4d. Intergrowth of green malachite with brown iron hydroxides, preserving to some extent the original chalcopyrite and pyrite crystals in the ore. Sample ACH 160, reflected light, crossed polarising filters.

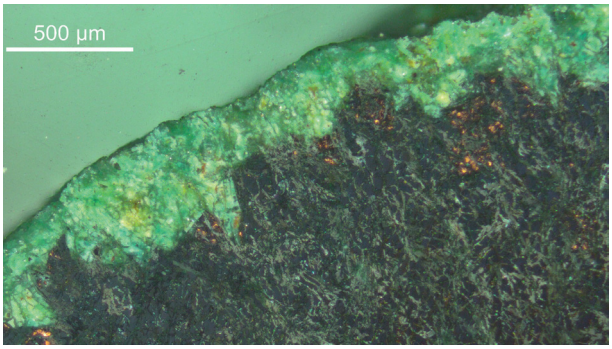

Fig. 4e. Rim of malachite surrounding a core of covellite. Sample ACH 98, reflected light, crossed polarising filters.

had been broken into its current size, before being discarded and buried in the soil.

Screening analysis using pXRF on the polished sections identified cobalt as a minor component in some fragments, particularly the brown ore. This was confirmed by subsequent SEM-EDS analysis of residual pyrite which showed consistently about 1–2wt% Co, which also carries through to the secondary iron hydroxide minerals. Accordingly, the two 'brown' ore samples ACH 116 and ACH 118a analysed by neutron activation (NAA analyses MA-133046 and MA-13304, Kunze/Pernicka, this volume, 391–418, table 3) have exceptionally high bulk concentrations of cobalt, namely 0.98 and 0.38% respectively.

While the overall mineralogy of the ore appeared relatively consistent, with copper and iron the main metals and either sulphur or hydroxide as anions, there were a few rare mineral identifications. The green ore sample ACH 69, consisting primarily of chalcocite and malachite, had a grain of native gold with about 10wt% silver and 1wt% copper. Its size, of ca. 10µm in diameter, would have made this impossible to recover mechanically, and its unique presence among all analysed ore fragments indicates that the overall gold content of the ore would not have been noticeable to the ancient smelters. Indeed, neutron activation analyses (Kunze/Pernicka, this volume, 391–418) show that the average gold concentration in ore samples from Akladi Cheiri ranges from 0.025 to 7.2µg/g, which is high according to modern standards but



Fig. 5. Fragments of a large ceramic vessel from Akladi Cheiri. The dark-coloured part still preserves its original carbon-black surface while in the light-coloured piece this is burnt off; note also the heavily slagged part on its lower inside (bottom left). Outside view (top) and inside view (bottom) of the same sherds.



Fig. 6. Cross sections through slagged ceramic fragments. Note the large quartz and feldspar inclusions (white) in the ceramic matrix (grey), the slag (dark, 6a) and the copper prill (bright, 6b).

certainly not detectable for chalcolithic miners and smelters.

Similarly, a single cluster of tiny cassiterite particles (SnO_2) in sample ACH 116a, a brown ore, would not have had any impact on the composition of the smelted metal. The same sample also



Fig. 7. The only preserved crucible from Akladi Cheiri. Note the intense vitrification on the lower left inside.

contains a grain of bastnaesite, a rare-earths fluorocarbonate with about 25wt% each of cerium and lanthanum, and about 4-5wt% neodymium.

Slagged Ceramic

The main metallurgical finds from the excavation in Akladi Cheiri are the estimated 300 pieces of ceramic from Pit 28 with various stages of heat impact, vitrification and slag attached to them, found among large quantities of other finds such as 'normal' pottery, green and brown ore pieces, and unfired trampled clay fragments (Leshtakov et al., this volume, 89–120). The highly-fired and slagged pottery fragments are otherwise normal ceramic matching the range of fabrics and shapes seen elsewhere in Late Neolithic and Early Chalcolithic contexts in Akladi Cheiri. Often, the vitrification and slagging affect old breaks of the ceramic; and in several cases fragments of one and the same vessel show strongly different vitrification and slagging (*fig. 5*). Taken together, these observations demonstrate that these are not normal crucible fragments, but instead that sherds of regular pottery were re-used in a metallurgical context. In total, 14 fragments were analysed, all from Pit 28, ranging in appearance from ceramic sherds with an adhering slag layer clearly separated from the ceramic itself (*fig. 6a*; e.g. ACH 14a, 119a, 126 and 126b, see *fig. 2*), sometimes including prills of metallic copper (*fig. 6b*) to fully mangled pieces with

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	FeO	CuO
Inside top, bloated	2.5	1.6	20.0	60.5	0.2	4.9	1.6	0.6	6.5	1.7
Inside, bloated	2.6	1.7	19.7	61.3	0.2	4.3	1.6	0.6	7.1	0.8
vitrified ceramic	2.5	1.7	19.4	63.0	0.2	3.7	2.0	0.7	6.1	0.3
Bulk ceramic, middle	2.4	1.4	19.7	61.4	0.2	5.2	1.5	0.7	7.0	0.5
Bulk ceramic, outside	3.3	2.1	19.7	60.6	0.3	6.1	1.7	0.5	5.6	0.2
Slag, bulk layer	1.0	3.0	6.9	41.2	2.7	2.4	8.6	0.3	15.4	18.4
Transition ceramic slag	1.4	1.1	13.4	69.6	0.6	2.8	2.3	0.8	6.1	1.8
Inside top, bloated	2.9	1.3	18.8	62.6	0.2	4.2	2.5	1.0	6.2	0.1
Bulk ceramic, middle	2.2	1.4	16.7	65.6	0.2	5.1	2.0	0.7	5.9	0.0
Bulk ceramic, middle	2.4	1.5	16.6	65.3	0.3	4.8	2.1	0.8	6.1	0.1
Bulk ceramic, outside	2.2	1.9	16.6	63.3	0.4	5.4	4.0	0.7	5.3	0.1
Bulk ceramic 574	1.9	1.6	16.8	65.5	0.3	4.7	1.5	0.9	7.0	0.0
Bulk ceramic	1.4	1.8	15.9	65.8	0.5	3.7	1.8	0.9	8.3	0.0

Table 1. Composition of the slagged ceramic fragments (matrix with inclusions) as determined by area analyses using SEM-EDS. Two sets of 5 analyses across the profile are given, for ACH 119a (top rows) and 126b (middle rows, in addition to the slag layer at the inside top). Data in wt% normalised to 100 to compensate for porosity. Note the increased copper content in the bloated ceramic, and the increased levels of magnesia, phosphate, lime, iron and copper oxide in the slag. Sample 574 (bottom 2 rows) is the only crucible found at Akladi Cheiri; apart from a slightly higher iron oxide content it has the same composition and fabric as the other pottery.

no discernible ceramic surviving apart from irregular bits embedded in the slag (ACH 118a, c). Only a single proper crucible (ACH 574) was identified among the material (*fig. 7*); see Leshtakov et al., this volume, 89–120). Interestingly, it is made from the same clay as the other pottery, including the feldspar-rich mineral inclusions, and does not show evidence for organic temper as is often the case in early crucibles from the Middle East (Martinón-Torres/Rehren 2014, 114, 123).

The ceramic consists of a relatively large proportion of fine matrix with a few but large mineral inclusions; most of these are feldspars, both potassium-rich alkali feldspar and plagioclase. The fabric is highly fired, with a clear thermal gradient across the ceramic. Typically, the outer (convex) part is less vitrified, while the inner (concave) surfaces are increasingly vitrified and reaching a fully bloated stage at the slag contact (*fig. 8*). The composition of the ceramic is 15 to 20wt% Al_2O_3, 2-5wt% each Na_2O and K_2O, 1.5 to 2wt% CaO, and ca. 5 to 7wt% FeO (*table 1*).

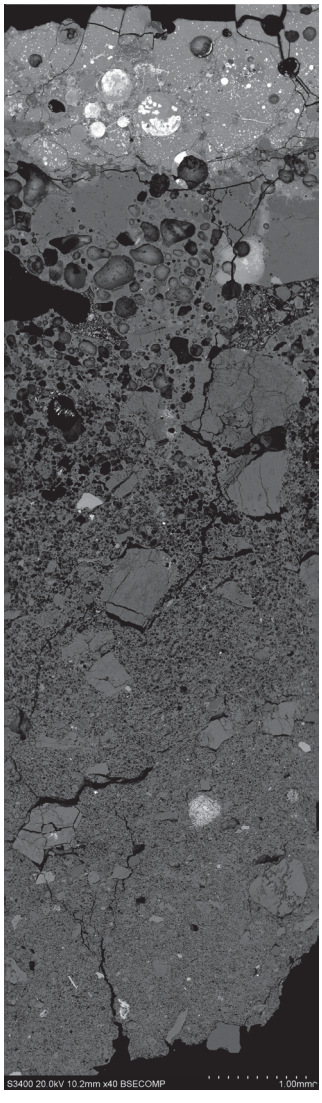

Fig. 8. Full profile through a slagged crucible fragment, with copper-rich slag layer at the top (light grey with bright inclusions), a bloated and fully vitrified contact zone, and increasingly less vitrified ceramic towards the bottom. Note the large feldspar and quartz inclusions in the ceramic body. Sample ACH 126, montage of several SEM-BSE images.

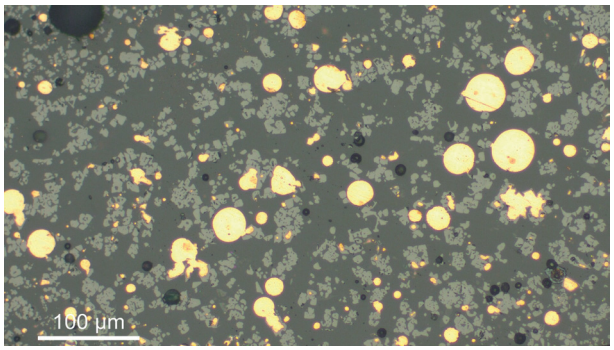

Fig. 9a. Cluster of copper metal (bright yellow) and magnetite (light grey) in a glassy slag. Sample ACH 118a, reflected light.

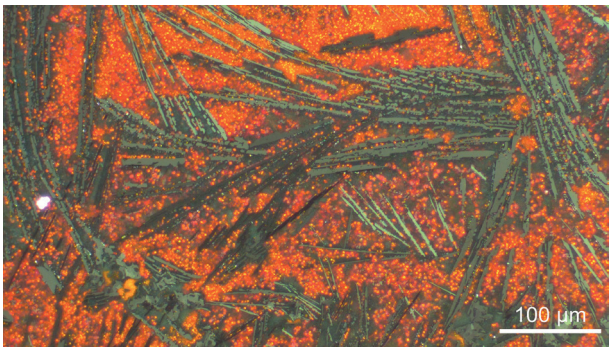

Fig. 9b. Crystals of delafossite (elongated particles in various grey shades) in a glassy slag matrix with countless small cuprite crystals (bright red). Sample ACH 125, reflected light, crossed polarising filters.

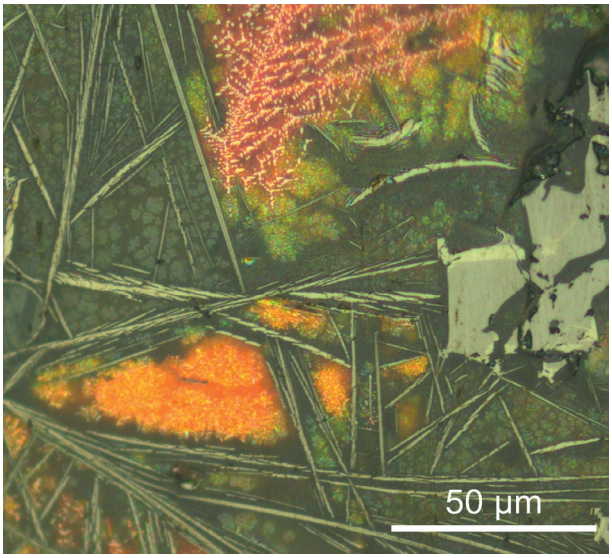

Fig. 10. Cuprite crystals in different grain sizes, ranging from relatively large dendritic (red, top) to smaller (orange, lower centre) to yellow and green sub-microscopic (fringes on the red dendrites). Sample ACH 119a, reflected light, crossed polarising filters.

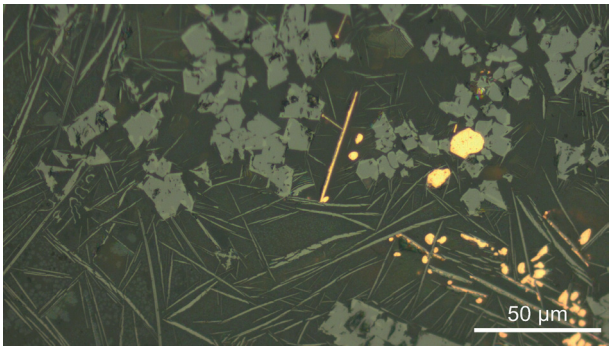

Fig. 11. Metallic copper (bright, centre and bottom right) replacing delafossite (needle-like, grey).

The Slag

Initial results had already shown the slag to consist of fayalite and magnetite with inclusions of matte and copper metal in a glassy to microcrystalline matrix, a composition typical of early copper smelting (Rehren et al. 2016). The investigation of a wider range of samples now highlighted the high degree of variability of composition and conditions of formation both within and among the samples. Some (e.g. ACH 118a, c) preserve evidence of highly reducing conditions, with no copper oxide phases but widespread inclusions of copper metal prills and newly-formed magnetite clusters (*fig. 9a*). Others are much more oxidised, with frequent delafossite and cuprite as well as magnetite (*fig. 9b*); and yet others are rich in various copper-iron and copper sulphides, but with large olivine crystals and magnetite. A few selected samples are presented below in more detail, together with SEM-EDS analyses of slag, fayalite and magnetite (*table 2–4*).

ACH 118a, 118c: Both samples are highly vitrified and broken-up ceramic fragments with glassy slag formed under strongly reducing conditions. There are numerous copper metal prills ranging in diameter from millimetre size to sub-microscopic. Copper sulphides, both chalcocite and covellite, are present but rare. The strongly reducing conditions are most strikingly evident from the lack of copper oxide and the formation of nano-sized copper metal prills in the melt. ACH 126 is similar. All three samples show frequent particles of residual quartz in the glassy slag matrix.

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2	MnO	FeO	CoO	CuO	MoO_3
ACH 123 (fayalitic)	0.7	1.6	5.2	35.2	1.8	0.8	1.6	5.5	nd	nd	46.5	nd	0.3	0.9
	0.4	2.3	3.2	32.3	1.6	0.7	1.6	4.2	nd	nd	51.6	nd	1.0	1.3
	0.5	1.8	3.4	32.8	1.8	0.5	1.6	5.0	nd	nd	50.7	nd	0.5	1.3
ACH 123 (glassy)	0.9	2.8	6.3	48.7	3.3	0.1	3.9	8.7	0.5	nd	16.6	nd	8.4	nd
	1.1	2.2	8.4	46.9	3.1	0.2	4.3	7.0	0.3	nd	14.7	nd	11.9	nd
	1.1	2.6	6.4	45.3	3.8	0.1	3.8	8.7	0.4	nd	18.1	nd	9.7	nd
ACH 118	0.7	3.7	8.7	45.5	2.1	nd	2.4	4.8	nd	0.4	22.7	2.7	6.4	nd
ACH 574	1.7	2.8	13.3	53.4	0.8	0.1	4.3	7.9	0.6	0.2	4.2	0.3	9.8	nd
	1.2	2.3	10.9	45.2	1.1	0.1	2.1	3.7	0.8	0.4	5.2	0.1	27.0	nd

Table 2. SEM-EDS area analyses of slag from Akladi Cheiri. Analysed area size varies depending on the size of material exposed in the section. All data calculated using oxygen by stoichiometry and re-cast to 100wt% to compensate for porosity and variation in beam intensity; nd = not detected. ACH 574 is a sample from the only crucible found at Akladi Cheiri; due to the thin layer of vitrified material this was analysed only using spot mode, effectively capturing a volume ca. 5 to 10µm in diameter. Note that this sample has no elevated iron oxide content compared to the ceramic composition (see above, table 1).

ACH 119a, 125; 126b: These samples formed under more oxidising conditions; they have a predominantly glassy slag matrix with relatively large amounts of magnetite and delafossite, as well as areas rich in cuprite. Here, the effect of crystal grain size on the colour of the cuprite is remarkable; relatively coarse crystals, with diameters not much below 1µm, are the common blood red colour (e.g. Freestone 1987). However, smaller crystals are more orange than red, and even smaller particles take a clear yellow colour, and finally a green shade (*fig. 10*). This range in colour of the same phase due to different crystal grain sizes is something seen before, but not well documented, even though the orange colour of cuprite has been regularly produced in 1st mill. AD glass (e.g. Heck/Hoffmann 2002). ACH 119a shows metallic copper replacing delafossite while maintaining the original shape of the oxide mineral (*fig. 11*). Again, quartz particles are relatively frequently seen in these samples.

ACH 123 is an example of a ceramic sherd with slag adhering which contains large fayalite and magnetite crystals and copper- and copper-iron sulphide inclusions as well as copper metal. The fayalite crystals are relatively blocky in their shape (*fig. 12),* indicating a slow cooling;

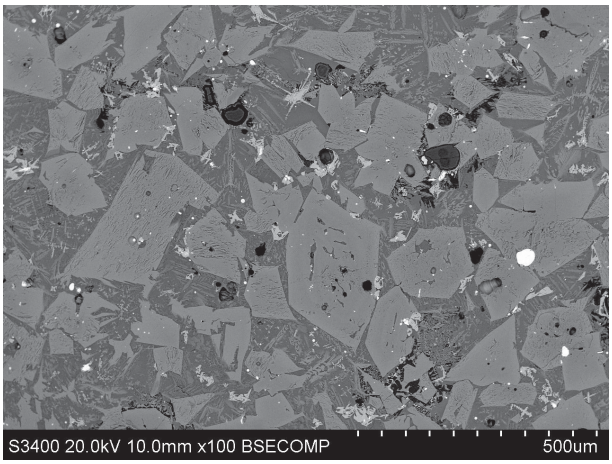

Fig. 12. Blocky fayalite (mid-grey) in a glassy matrix (dark grey) with dendrites of magnetite (light grey) and metallic copper prills (bright, centre right). Sample ACH 123, SEM-BSE image.

they contain around 4 to 7wt% MgO and 60 to 64wt% FeO; the balance is mostly silica, with less than 1wt% each phosphate and lime (*table 3*). The magnetite crystals in this sample are remarkable for their content of 14 to 18wt% MoO_3, 2 to 3wt% TiO_2 and around half of one percent V_2O_5 (*table 4*). Elsewhere, the slag is glassier and contains much less FeO and more SiO_2 as well as more copper. In line with the presence of copper-iron and pure copper sulphide there is no primary cuprite in this

	MgO	SiO_2	P_2O_5	CaO	FeO
ACH 123	5.1	31.7	0.8	0.6	61.8
	3.9	31.5	0.5	0.7	63.4
	7.2	32.8	0.1	0.7	59.2
	5.6	32.2	0.4	0.8	60.9
ACH 118	7.8	32.9	1.0	0.1	58.3
	6.7	32.9	0.7	0.2	59.5
	5.7	32.3	0.5	0.3	61.2
	10.4	32.4	nd	nd	57.2

Table 3. SEM-EDS spot analyses of four different fayalite crystals in samples ACH 123 and ACH 118, respectively. Note the relatively high levels of magnesium. All data calculated using oxygen by stoichiometry and re-cast to 100wt% to compensate for variation in beam intensity; nd = not detected.

	MgO	Al_2O_3	SiO_2	TiO_2	V_2O5	MnO	FeO	CoO	CuO	MoO_3
ACH 123	0.0	4.2	0.5	2.2	0.6	0.0	75.3	nd	nd	17.3
	0.0	3.9	0.3	2.7	0.6	0.0	74.5	nd	nd	18.0
	0.0	4.1	0.6	2.3	0.7	0.0	74.5	nd	0.4	17.5
	0.1	4.2	0.6	2.2	0.6	0.1	78.3	nd	nd	13.9
	0.3	4.2	0.4	2.1	0.4	0.1	78.7	nd	nd	13.8
	0.1	4.0	0.6	1.9	0.7	0.2	77.2	nd	0.2	15.1
ACH 118	0.7	10.9	0.7	1.4	0.9	nd	84.5	0.6	0.3	0.2
	0.3	11.2	1.0	1.2	0.5	nd	85.1	0.9	nd	nd
	1.1	20.5	0.8	0.8	1.0	0.2	74.5	0.8	0.1	0.4
	0.5	4.7	1.1	0.2	0.1	nd	91.3	1.1	0.3	0.9
	2.5	2.0	1.3	0.3	nd	0.4	85.4	6.6	1.5	nd
	3.0	8.7	1.8	0.3	0.1	0.5	76.1	8.3	1.0	0.2

Table 4. SEM-EDS analyses of six magnetite crystals in samples ACH 123 (top, rich in molybdenum) and ACH 118 (bottom, partly hercynitic, partly rich in cobalt), respectively. All data calculated using oxygen by stoichiometry and re-cast to 100wt% to compensate for variation in beam intensity; nd = not detected.

sample. Samples ACH 14a and ACH 118 have a similar mineralogy; however, in the latter the main accompanying element in magnetite is cobalt, reaching more than 6wt% as oxide, and nearly half of one percent in several of the copper metal prills. Elsewhere in the same sample, the magnetite has no cobalt but is hercynitic, ranging from 10 to 20wt% Al_2O_3 (*table 4*) – further evidence for the very heterogeneous nature of the slag in this sample, as well as in others.

The vitrification layer on the inside of the only proper crucible fragment found at Akladi Cheiri (ACH 574) differs fundamentally from the slag of the other nine samples, as described above. Firstly, it is rather thin and has neither elevated iron oxide nor sulphide inclusions. Instead, it is more similar to the composition of the ceramic (see *table 1*), in that it has more than 10wt% Al_2O_3 and only about 5wt% FeO, compared to 15 to 50wt% FeO in the proper slag. We therefore interpret this as vitrified ceramic, heavily contaminated with copper metal from the charge and fluxed by fuel ash as indicated by the much higher lime content compared to the ceramic body, but not as metallurgical

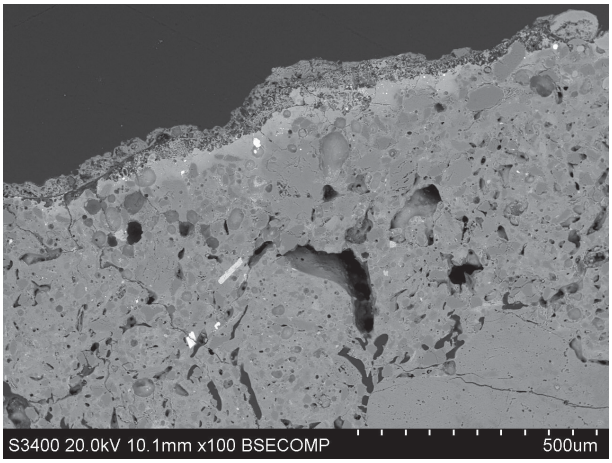

Fig. 13a. Cross section through the inner surface of the crucible, showing vitrification of the ceramic but only very limited enrichment in copper (bright, centre near top). Sample ACH 574, SEM-BSE image.

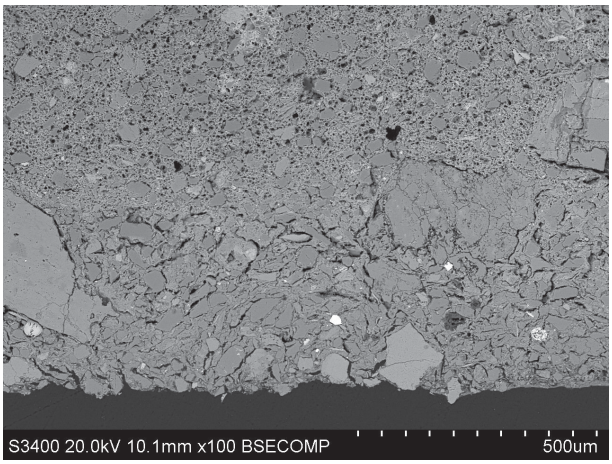

Fig. 13b. Cross section through the outer surface of the crucible, showing a thin outer layer of quartz (dark grey) and feldspar (light grey) particles (bottom). Note the vitrified ceramic matrix. Sample ACH 574, SEM-BSE image.



Fig. 14. Cross section through heavily corroded metal bead. The different colours of the various corrosion products preserve the original texture of a folded sheet of copper. Sample ACH 137, reflected light, crossed polarizing filters, montage of three individual micrographs.

slag from a smelting process (*fig. 13a*). The ceramic body of this vessel is made from the same fabric as the other sherds, with the same feldspar inclusions and no organic temper; however, the outer surface appears coated in a layer of finely-crushed quartz (*fig. 13b*), which has not been seen in other samples.

Metal, Bead/Lump ACH 137: This small bead or metal lump from a Late Neolithic context has a diameter of about 5mm. It appears to have been made by bending a flat piece of metal onto itself (*fig. 14*). The metal is mostly corroded and only preserved in small parts. The bulk of the corrosion is malachite and related phases, surrounded by a thin layer of pure copper phosphate (green-blue in XPL: 68wt% CuO, 31wt% P_2O_5 and 1wt% CaO), probably outlining the original surface of the metal, and then an outer layer of copper silicate (olive green; presumably hydrous, normalised SEM-EDS composition 46wt% SiO_2, 54wt% CuO, and ca. 0.5wt% CaO. The mineral chrysocolla has ca. 40wt% SiO_2, 47wt% CuO and 10wt% H_2O as well as minor oxides; re-casting this composition water-free will result in almost exactly the SEM-EDS data obtained here).

Interpretation

The results from the investigation of the ore fragments and the slagged ceramic can now be used to explore the main questions set out above:

(1) whether the slagged ceramic can be confirmed as evidence for the regular smelting of copper metal;
(2) whether the green and brown mineral lumps can be linked to the extraction of metal and therefore rightly called 'ore', as opposed to green (gem) stones used for bead or pigment making;
and, if both questions are answered positive:
(3) whether the two materials can be linked into one production sequence beyond reasonable doubt, and to the ore deposits of Medni Rid nearby;
(4) how much we can say about details of this unparalleled smelting technology; and
(5) how this fits into the wider picture of the emerging metallurgy in the Balkans and beyond.

(1) Smelting Slags?

The composition of the slag is fully consistent with other known early copper smelting slags, and is clearly not just the result of some over-firing of domestic ceramic in a non-metallurgical context, or from the simple re-melting of existing metal. Key evidence for this is the very high iron oxide content of most slag areas, reaching nearly 50wt% in some samples and forming numerous clusters of magnetite and fayalite. Compared to the underlying ceramic, which has less than 10wt% FeO, this is very strong indication that the material processed here was rich in iron oxide which then contributed to the slag formation. Similarly, the presence of copper-iron and copper sulphides in numerous samples, together with magnetite forming from the progressive oxidation of the iron from the sulphide phase, is strong evidence for the smelting of a sulphidic ore, such as chalcopyrite or bornite. Other samples lack these sulphides, but instead are rich in delafossite, cuprite and magnetite; this assemblage has been previously identified as typical of Chalcolithic copper smelting (e.g. Bachmann 1982; Müller et al. 2004; Radivojević et al. 2010). Finally, while an increased iron content could feasibly originate from the re-melting of iron-rich raw copper, the presence in numerous slag samples of elements such as cobalt or molybdenum which are unlikely to alloy with copper metal further points to the processing of complex ores rather than the re-melting of previously smelted 'dirty' copper.

A remarkable feature of the analysed assemblage is the chemical and mineralogical heterogeneity of the different slag fragments. Some are dominated by molybdenum as a key associated element, others by cobalt; yet others have neither of these two, but contain only copper and iron. Even within individual samples, within a few millimetres the composition of magnetite can vary widely, from hercynitic with a little titania to cobaltiferous magnetite (see above, *table 4*). The mineralogy varies from strongly reducing to relatively oxidising, and from rapid cooling resulting in the formation of a glassy slag with small and predominantly skeletal crystals to more slowly-cooled samples with blocky crystals of fayalite and magnetite. We interpret this heterogeneity as indicating the presence in this assemblage of remains of multiple separate smelting events, using ore batches of different compositions and under different smelting conditions. Of course, it would also be possible to argue for a single smelting event here, scaling the micro-heterogeneity seen within individual fragments up to the differences seen among different fragments, and the known differences in redox conditions across an early smelting installation. Without a clearer separation of the slagged ceramic fragments into separate contexts it is not possible to conclusively argue for one or the other of the two scenarios; on balance we believe it more probable that these sherds were accumulated over a period of time, from separate smelting events.

(2) Ore or Green Stones?

The ore fragments can be shown to form part of a continuum ranging from partly weathered chalcopyrite and pyrite with quartz to almost pure aggregates of malachite. The presence of numerous intermediate stages in the transformation of primary sulphidic ore to the colourful green and

brown secondary minerals indicates that the pure green fragments are just the extreme end of this continuum. It is clear that these fragments were brought to the site by the Chalcolithic inhabitants of the settlement, as the local geology is dominated by sediments, sand and soil. The systematic differences in particle size (larger for brown ore than for green ore) indicates a progressive crushing of originally larger lumps of rock to obtain a high-grade 'green' concentrate, discarding all fragments that are deemed not suitable for the intended purpose. There is no evidence for the production of malachite beads at Akladi Cheiri, such as blanks, semi-finished or broken beads, while we have established that the slagged ceramic fragments are from the smelting of copper metal. It is therefore reasonable to assume that the green mineral was intended to be smelted for copper, and hence rightly deserves to be called ore. The prevalence of brown fragments among the excavated material is therefore not surprising, as this very iron-rich material would have been recognised as not being suitable for copper smelting and hence discarded as waste; however, the presence of almost pure chalcocite/covellite nodules appears counter-intuitive among this discarded material if the main purpose of the operation was to produce copper. However, while these now show a rich green on their surface, we argue that this is only due to the weathering of the material during deposition in the soil, and that they were originally a dark steel blue, and consciously discarded by the Chalcolithic craftsmen as unsuitable for smelting in the context of a smelting technology focused on the processing of pure oxidic copper ore, such as malachite. A similar situation has been observed in Chalcolithic Shar-i Sokhta in eastern Iran, where also a sulphide-bearing 'green' oxidic copper ore was smelted. There, massive cakes of copper-rich matte formed between the copper metal and the slag and were discarded as unsuitable for further processing (Hauptmann et al. 2003). Here, the massive pure copper sulphides are clearly a geological formation and not matte, indicating that the smelters at Akladi Cheiri carefully selected and removed any sulphide minerals as much as possible from the batch. With the exception of a few small fragments of pure malachite, such as ACH 117, ACH 160 or ACH PV which might have been simply lost because of their small size, all other green and brown 'ore' fragments should probably be considered waste or tailings rather than ore. Still, they represent the original geological material used for smelting copper, even if the relative proportions of 'real ore' malachite and 'discarded waste' is heavily skewed in the studied assemblage towards the latter.

A remaining conundrum is the frequent occurrence of both green and brown ore/waste minerals in Late Neolithic and Early Chalcolithic contexts. At present, there is no indication for the smelting of copper in eastern Bulgaria during the Late Neolithic period, which makes it difficult to argue that these finds from Late Neolithic contexts are indeed ore tailings. However, similar pieces of copper ore were also found at other Late Neolithic sites in eastern Bulgaria (Kunze/Pernicka, this volume, 391–418), and may have been related to the cold working of green minerals for beads.

(3) Linking Slag, Ore Tailings, and Medni Rid

The analyses of the ore tailings have shown them to be dominated by just a few non-volatile elements – iron, copper, sulphur, silica, and occasionally minor amounts of cobalt and traces of molybdenum. The composition of the slag matches this spectrum very well, beyond the contribution made by vitrified ceramic and fuel ash which account for the bulk of the slags' composition. In particular, the presence of cobalt and occasionally of molybdenum oxide in freshly-formed magnetite, and the presence of sulphide minerals as well as gangue quartz and some haematite clusters all indicate that the ore and the slag are consistent with each other – this type of ore upon smelting would have produced this type of slag. However, the small quantities of slag indicate that the smelted batches of ore would have been much richer in copper than the ore fragments found in the excavation. It is reasonable to assume that the actually smelted ore was much richer in pure malachite which leaves little if any slag, and that the discarded material left for archaeologists to find represents the lower end of the spectrum of mineral assemblages brought to the site: the ore tailings rather than the ore proper.

Lab no.	Orig. ID	Material	Context	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
Akladi Cheiri								
MA-151990	ACH 574.5	Copper globule from crucible	Pit 28	2.0541	0.83184	18.814	15.650	38.647
MA-171051	ACH 118	Slag on pottery	Pit 28	2.0326	0.82476	18.955	15.633	38.527
MA-171054	ACH 126	Slag on pottery	Pit 28	2.0450	0.82926	18.852	15.633	38.551
MA-171056	ACH 178	Slag on pottery	Pit 28	2.0604	0.83429	18.757	15.649	38.646
MA-171056	ACH 179	Slag on pottery	Pit 28	2.0656	0.83695	18.682	15.636	38.590
Sozopol								
MA-171049	Sample 1	Copper on pottery	Sozopol, harbour, A, no. 1, EBA	2.0753	0.83859	18.662	15.650	38.729

Table 5. Lead isotope ratios of slag samples and a copper prill from the Late Chalcolithic site Akladi Cheiri. Also included is a copper sample from an Early Bronze Age crucible found in the harbour of Sozopol.

Geologically, the ore fragments represent a continuum of material consistent with gossan formation from some primary ore body rich in chalcopyrite and pyrite. The proximity of Akladi Cheiri to the copper-rich mountain ridge visible from the site on the horizon further makes it plausible that the ore processed at Akladi Cheiri was locally obtained.

Although both trace element patterns and lead isotope ratios exhibit large variations in the ore and slag samples (*table 5*), they can both be securely related to the ore deposits of the Medni Rid region (Kunze/Pernicka, this volume, 391–418). Indeed, the large variation of lead isotope ratios due to relatively high uranium concentrations in the copper ore is an unmistakeable indicator, if a suite of sample analyses is available as in this case (*fig. 15a–c*).

Molybdenum was not included in the neutron activation analyses, because it is not a useful element for relating copper metal to copper ore deposits. It is a so-called lithophile element that partitions preferentially into the slag on copper smelting, as seen in one of the slag samples. However, in future studies it would be useful to include it in comparisons of copper ore samples from Akladi Cheiri with ore samples from the Medni Rid region, and thus to add a useful parameter for provenance analysis of copper ores from archaeological sites.

(4) The Smelting Technology

The samples analysed provide a picture of an operation based on batches of ore which contained only a small amount of slag-forming minerals; the majority of sherds from Pit 28 show a sustained heat impact but only very limited and localised slagging. Some sherds are heavily vitrified around corners or edges, and most have a strong thermal gradient decreasing from the inner, concave and fully vitrified and bloated side to a far less affected outer convex side, where only the matrix shows vitrification but the feldspar inclusions did not begin to melt. Only one crucible was identified among all 300+ sherds, characterised by vitrification and contamination of its inside with copper metal, but no evidence for increased ore gangue elements such as iron, cobalt or sulphur. The vast majority of the vitrified and slagged ceramic sherds therefore cannot have been crucibles in the classical sense of ceramic vessels used to contain the metallurgical reaction (Rehren 2003; Bayley/Rehren 2007). The heterogeneous composition of the slag, and the very variable redox conditions are all consistent with very early small-scale metallurgy where the temperature of the process and the quantity of slag present are not sufficient to ensure a homogenous melt, as was the case in later slag-forming metallurgy. Similar observations have been made from crucible-bound

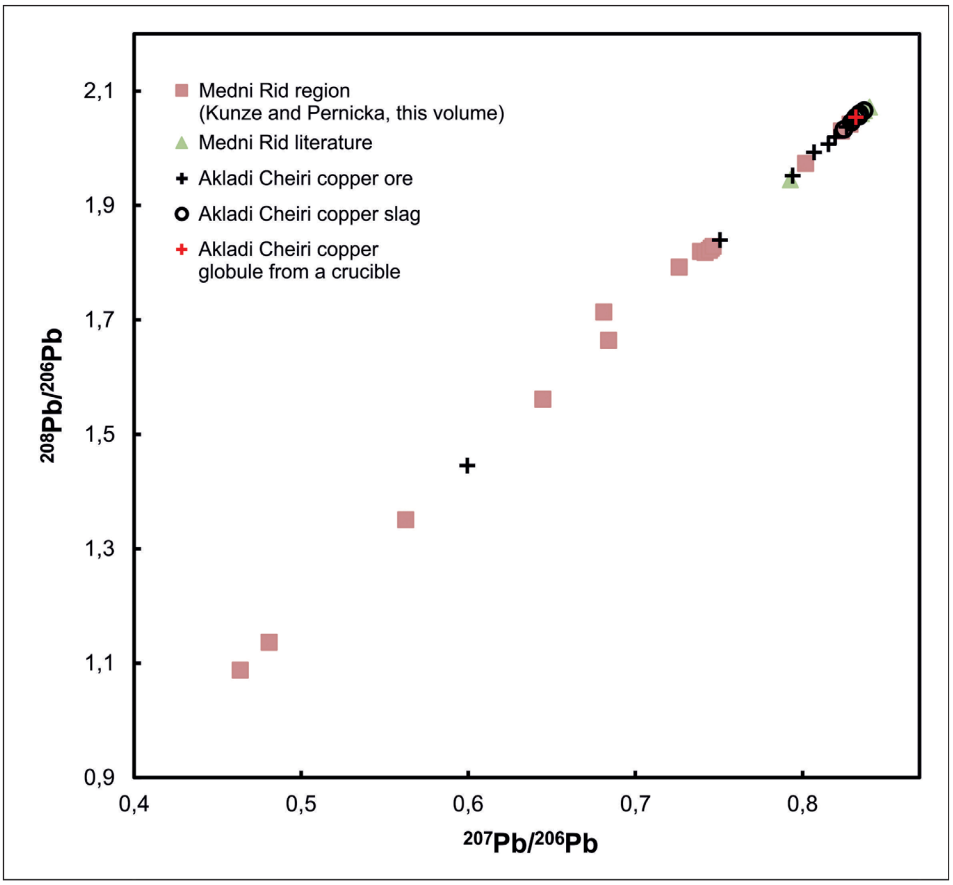

Fig. 15a. Lead isotope ratios in different materials from Late Chalcolithic contexts at Akladi Cheiri compared with copper ores from the Medni Rid region (Kunze/Pernicka, this volume, 391–418). Some of the copper ore samples from Akladi Cheiri contain radiogenic lead that plots along the same trend as the copper ores from the Medni Rid region. Since such radiogenic lead is due to uranium heterogeneously distributed in the ore body (even on the microscale), the smaller range of lead isotope ratios in slag samples suggest that smelting resulted in a homogenisation of different ore samples.

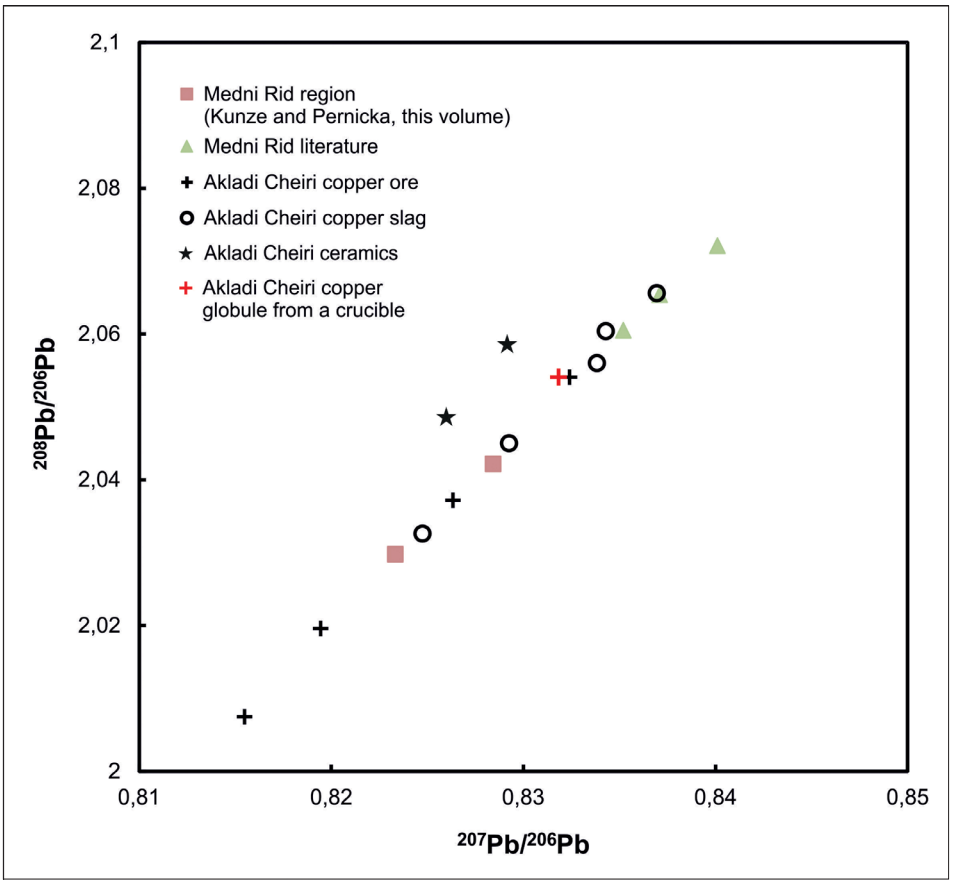

Fig. 15b. Detail of Fig. 15a that shows that the local ceramic material has a somewhat different lead isotope signature in that it contains more thorogenic lead which is geochemically consistent, as the average Th/U ratio in the Earth's crust is ca. 4, while it is much lower in copper ores impregnated with uranium. It also shows that the lead isotope ratios in the slag samples are not affected by admixture of ceramic materials indicating minimal interaction of slag with the ceramics. The copper prill from the crucible ACH 574 matches the ore and slag samples perfectly, indicating that the crucible was used to melt copper produced on the site.

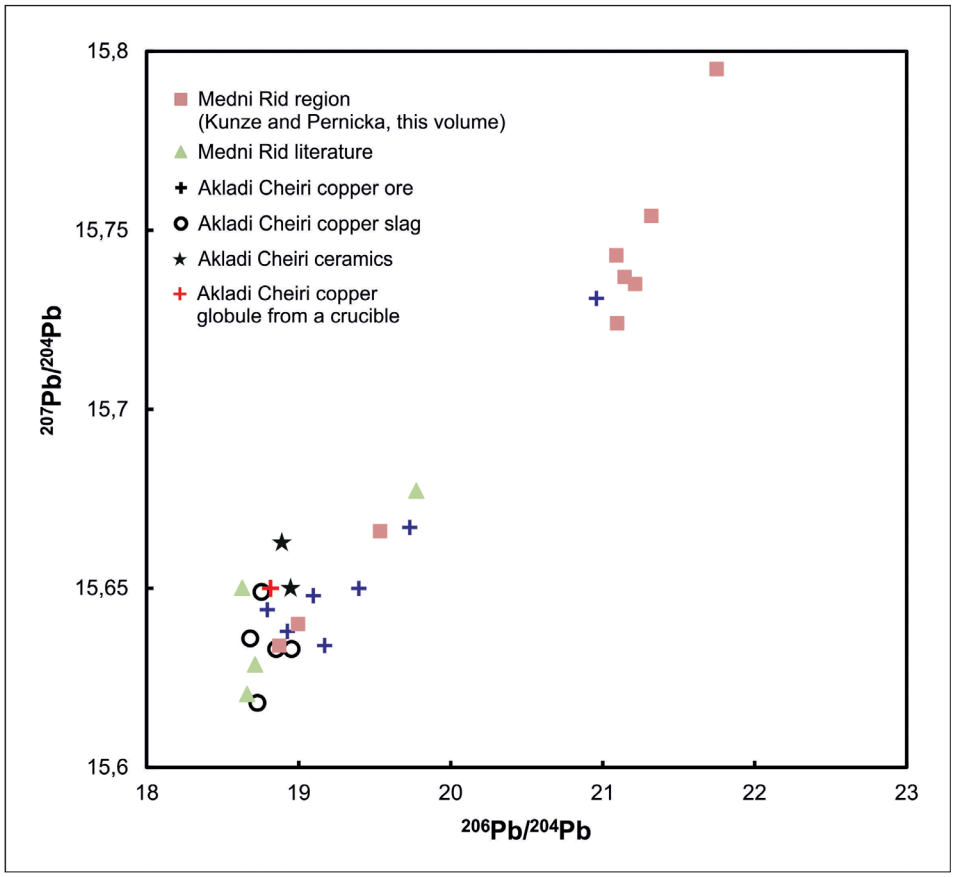

Fig. 15c. Alternative presentation of the lead isotope ratios of materials from the Late Chalcolithic site Akladi Cheiri. Since in this diagram only uranogenic lead is plotted, there is no significant difference between the ceramic materials and the copper-containing ones. The small spread of lead isotope ratios in the slag samples compared to the wider spread in the ores again suggests that many small pieces of copper ore were smelted together and thus homogenised the lead isotope composition.

smelting elsewhere (e.g. Nevalı Çori etc. in Anatolia); however, there is no crucible here in which the smelting could have taken place. Only one crucible was found with an adhering globule of copper which was undoubtedly melted. Its chemical composition and trace element pattern is entirely consistent with ore samples from Akladi Cheiri and with copper mineralisations in the Medni Rid region (Kunze/Pernicka, this volume, 391–418), but it was most likely used for re-melting and casting copper, not for smelting it. Close inspection of the morphology of the ceramic fragments, the impact of heat and slagging on some fragments but not others of the same vessel, and the pattern of slag adherence going around old breaks strongly indicates that the sherds were already broken when they became part of the metallurgical process. One possible interpretation for this would be a ceramic-lined smelting pit in which a batch of malachite was smelted so that hardly any slag formed, and only heat and fuel ash affected the majority of sherds. Slag most likely formed only in some areas of the smelting batch where the beneficiation of the ore was not ideal, and only in small amounts which we now see attached to the sherds.

Such an installation has not been found in the excavation, but most likely it would have been ephemeral, particularly if sunken into a sandy soil which would not preserve traces of heating. The purpose of the ceramic lining could have been two-fold; firstly, to prevent moisture from the soil to get into the smelting hearth, and secondly to provide an already-fired surface of the reaction chamber, avoiding the loss of thermal energy for the endothermic baking of clay to ceramic. Instead, the maximum amount possible of the thermal energy released by the fuel in the hearth would have been directed towards driving the smelting process. Rehder (1994) pointed out that the air stream provided by blow pipes is moist and deprived of oxygen compared to ambient air, severely limiting the amount of useful energy that can be released by the burning fuel. Reducing heat loss is therefore of prime importance for the very early stages of metallurgy, and using pre-fired ceramic sherds to line and insulate the smelting hearth would have helped towards this goal. Such

a lining would also have prevented, or at least limited the collapse of the sandy soil into the hearth, which would have potentially trapped some of the smelted copper prills and reduced the overall yield of the smelt.

(5) Contextualising Akladi Cheiri

Over the last decades, early copper smelting has received a significant amount of attention, and a number of case studies have been published presenting various scenarios of incipient metallurgy. Geographically and chronologically the closest comparative examples are from the Balkans to the west of Akladi Cheiri, and from Anatolia to the south-east, across the Black Sea. The evidence from Belovode (Radivojević et al. 2010) and other Vinča culture sites in eastern Serbia is probably the closest in similarity currently known. There, too, an ore comprising predominantly malachite but also residual sulphides and slag-forming material was smelted under variable redox conditions, leading to the formation of delafossite-cuprite slag visually very similar to the oxidic slag seen here. The Vinča sites are also characterised by the absence of proper crucibles, while a few broken and secondarily slagged ceramic sherds could point to a similar arrangement of a ceramic-lined smelting hearth. Finally, the ore batches in the Vinča culture are also very variable in their mineralogy and content of minor oxides, suggestive of the exploitation of a gossan-type ore deposit.

The concept of a ceramic-lined hearth, in contrast, is best documented from Çamlıbel, an Early Chalcolithic site in north-central Anatolia (Schachner 2010). There, a succession of such hearths was found associated with several kilograms of copper slags (Rehren/Radivojević 2010). Even though a detailed and comprehensive study of this association has not been able to show a direct link between the hearths and the slag (Boscher 2016), the fact remains that these hearths were used for some pyrotechnological activity, and carefully lined with broken domestic pottery. It is tempting to see these smelting hearths as precursors to the smelting pit with ceramic collar as reconstructed by Golden et al. (2001, 958) for the Levant. Clearly, the proposed metallurgical technology here is consistent with contemporary technologies in use in the wider region, as well as providing an unparalleled level of preservation and richness of material to study.

Discussion

The reconstruction and contextualisation of the Late Chalcolithic metallurgy at Akladi Cheiri provides remarkable new insight into the level of skill and mastery at this early stage of an emerging craft. The very small quantities of slag present in the assemblage are testament to the richness of the ore, while the nature of the ore tailings allows us to characterise the nature of the smelted ore, as well as to appreciate the care taken in the beneficiation process. This was not a crude and haphazard undertaking, but a well-controlled and planned, probably even regular activity, embedded in its landscape and on a par with established practice elsewhere. Despite the good preservation of the material and the well documented and controlled excavation, several questions and uncertainties remain. The wide distribution of both green and brown ore tailings across Akladi Cheiri is probably the most pressing issue, as it spans both Early Chalcolithic and Late Neolithic contexts, while no metal use is known so far for the Late Neolithic period from this region. This material is clearly not in its original geological place of origin, but has been brought to the site and carefully processed with just the brown and dirty green material entering the archaeological layers. Since this material does not appear to have had any use in its own right, we assume that it represents waste or discarded material from the extraction of pure malachite. An alternative use of green copper minerals prior to their use as a copper ore could have been to produce either pigment or beads and other jewellery. The use of green stones for such purposes in the Balkans goes back several millennia (e.g. Todorova/Vajsov 2001, 13; Avramova 2002, 196; Parzinger/Schwarzberg 2005), although no specific evidence for it has been found at Akladi Cheiri, or the immediate vicinity. A similar situation is known from the somewhat earlier copper smelting events in the Vinča culture in eastern Serbia, where copper smelting appears to have

evolved from the processing of green minerals extracted originally for jewellery and other purposes (Radivojević et al. 2010; Radivojević/Rehren 2016).

While there is at present no precursor native copper metallurgy known in the Medni Rid region from which this technology could have developed, it is obvious that it was only the beginning of a metallurgical tradition spanning many millennia. Mining for copper has given Medni Rid its name, and the study of the metallurgy of the region is only in its infancy. Two recent papers focussing on the Rosen ore field present a series of analyses of copper slags tentatively dated to the 6th cent. BC to 4th cent. AD (Stavrakeva/Tzankova 2016a; Tzankova et al. 2016), and identified slag with a composition and mineralogy similar to some of the slags seen in Akladi Cheiri; of particular interest is the detected presence of relatively high concentrations of lanthanum, cerium and other Rare Earth Elements in some of the ore and slag samples. These REE concentrations not only bring to mind the identification of bastnäsite in the ore sample ACH 116a from Akladi Cheiri, but are high enough to lead Stavrakeva/Tzankova (2016b) to propose the large-scale exploitation of the prehistoric and Roman period slags from the Rosen ore region as a source of copper and REE for modern industry.

Conclusions

The analysis of ore tailings, slagged ceramic and a metal bead have provided the basis for the reconstruction of an established and well-conducted Late Chalcolithic copper metallurgy. According to this scenario, early miners brought weathered green and brown ore from the Medni Rid mountains to the settlement of Akladi Cheiri, where it was further beneficiated and any material deemed unsuitable for smelting discarded. These tailings enable us to link the slag from the ceramic pieces excavated in Pit 28 to a smelting operation based on a batch of very rich copper ore, most likely almost pure malachite with only minor amounts of slag-forming gangue and associated ore minerals. Intriguingly, the same green and brown ore tailings were also found in Late Neolithic contexts, even though there is no indication for any metallurgical activity in the Late Neolithic. The ore is consistent not only with the slag, but also with a local origin from the Medni Rid ore deposits, as indicated by minor components such as Mo, Co, and REEs, and their trace element and lead isotope patterns. The presence of iron at low percentage level in some of the copper prills indicates strongly reducing conditions in some of the slag samples, while in others, the abundant presence of cuprite and delafossite points at much more oxidising conditions. The presence of relatively high amounts of iron oxide in almost all slag samples, and the presence of copper-iron sulphides in many of the reduced slags indicates that the beneficiation of the malachite was not entirely successful; however, even pure copper sulphide nodules, containing in excess of 60wt% copper were still discarded as waste, indicating that the conscious smelting of sulphidic ores was not yet mastered.

No smelting installation has been found so far; however, the analysed remains indicate that a ceramic-lined pit was used as smelting device. The scale of production is impossible to quantify, but would have been significant at least for the time, given the amounts of sherds and ore tailings excavated during rescue excavation. Overall, the material contributes fascinating details of the emerging copper smelting technology during the Late Chalcolithic period in Bulgaria and the wider Balkans.

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Analyses of Bone Remains from Wild and Domestic Animals from the Prehistoric Site Akladi Cheiri, Chernomorets

Late Neolithic, Chalcolithic and Early Bronze Ages

Keywords: bone remains, wild animals, domestic mammals, lion remains, Bulgaria

Late Neolithic

Characteristics of the Bone Sample: Traces of Human Activities

This study is based on a sample of 1437 bone fragments presented for processing in 2009. From all the bone remains of domestic and wild mammals, birds and fish 1166 fragments have been identified to the species level.

Predominant in the material of domestic and wild animals are remains of mandibles, *humeri*, *costae*, *metacarpals*, *tibiae*, *metatarsals* and, to a certain extent, pelvic fragments and *vertebrae*. This finding is not surprising as these are the most numerous bones of the skeleton or the ones most resisting to destruction in taphonomic context. The relatively small share of phalanges, especially of the second and third ones, could be due to the fact that they often remain in the skin.

The remains have the features of so-called kitchen middens, such as significant fragmentation of the bones in order to be suitable for consumption and culinary processing, numerous traces of skinning and cut-marks from butchering, and features of thermal processing. Notable is the fact that the bone remains of cattle are cut into larger pieces. On the other hand, the bone fragments of the smaller ruminants and domestic pigs are highly fragmented and shredded and to a lesser extent charred (it is likely that the smaller meat pieces together with the bones have been used for making broth). The latter might be the reason for the higher percentage of unidentifiable remains, whole bones are almost completely lacking. For cutting the slaughtered animals the longitudinal method of the dismemberment of the corpse has been used, as is still done nowadays. There are bones, including first and second phalanges of ungulates with signs of holes, perforated for the subtraction of medulla: a practice common in prehistoric times and recorded on numerous occasions from prehistoric bone samples that we have analysed over the years (Спасов et al. 2001).

Within the material, single human bones have been identified.

In addition, several bone tools have been found: a chisel made of the distal end of a *tibia* and an awl of sheep *metapodial*, sheep/goat *tibia* with an opening at the distal end (a stage of the traditional technology for working of bones which has been established by us on numerous occasions, which according to our previous studies used to exist from prehistoric to Roman times (Илиев et al. 1997).

The Ratio of Wild Animals to Domestic Animals and the Role of Husbandry and Hunting

Most of the bone fragments (1038) belong to domestic animals, while only 128 bones are of wild

	Domestic mammals						
	Cattle	**Sheep/Goat (unidentified)**	**Sheep**	**Goat**	**Ovicaprins (a total)**	**Domestic pig**	**Dog**
Number of bones	501	298	59	40	397	127	13
Min. number of individuals	31	17	7	6	30	17	4

Table 1. Distribution of domestic mammals from the Neolithic sample according to the number of bones and the number of individuals.

animals, from which 85 belong to wild mammals and the rest to wild birds (35) and fish. Several shells of the common Black Sea mussel have been recorded as well.

Remains of wild mammals represent a small share (less than 20%) of the bone volume of the domestic ones, even though the number of the wild species is not small at all. In this regard, the bone sample of the Late Neolithic stratum from Akladi Cheiri is identical to the features of another Late Neolithic site: Budzhaka, Sozopol (personal observation).

The calculated number of individuals of wild animals is estimated following Bökönyi (1970). The calculations indicate the presence of a total of 50 individuals of wild animals – from which 25 are mammals – which represents more than 50% of the number of specimens of domestic animals (83 specimens). This statistic shows once again that we should not compare mechanically the number of the calculated individuals for species recorded by single bone fragments only with the species documented by numerous bone fragments. In the first case, we could speculate this is the approximate number of specimens, while in the second this is more likely the minimal number of individuals. That is why the comparison between domestic and wild mammals in this investigation is based mostly on the number of bones rather than on the number of individuals.

Domestic Mammals

Cattle dominate among domestic animals. This is clear when comparing the number of bones and not so obvious when comparing the number of individuals. However, artificially separating small ruminants into three groups (*table 1*), owing to the inevitable impossibility to identify every bone to one of the domestic animals (sheep or goat), would increase artificially the minimum number of individuals of the *ovicaprins* (we should consider the fact that this regards the minimum or at least the approximate number and not the absolute number of calculated individuals). The high number of cattle bones indicates a well-developed (as compared to the general case) Neolithic farm for the region. This characteristic is similar to the features of the adjacent Budzhaka site near Sozopol (see above).

Owing to the lack of complete metapodials, the height of cattle is calculated using the combined method of Atanasov, Vasilev and Tsonev (Атанасов et al. 1980). For these calculations, a total of 74 measurements of the first *phalanges*, *astragali* and *calcanei* are taken. Similar to other, previous analyses made by us on Neolithic and Chalcolithic cattle (Spassov/Iliev 2014; Spassov et al. 2015), the cattle height varied greatly (104.69 to 144.08cm). This wide range of variation is explained by the presence of *primigenius* and *brachicerous* in height individuals (according to the criteria related to the modern cattle typology), as well as of intermediate between them individuals (the so-called 'crossbreads' in size). The three size types are found in a ratio of: 10.81:59.46:29.7.

In general, we could conclude, similarly to previous studies, the likely presence of unconsolidated breed (Spassov et al. 2015). The average height is generally similar to the one of other specimens from the country with similar age (Spassov/Iliev 2014; Spassov et al. 2015). However, in the sample the larger individuals are dominant. This is likely a sign of an initial stage of breeding activities which

	Wild mammels								
	Fox	**Badger**	**Wild boar**	**Red deer**	**Fallow deer**	**Roe deer**	**Aurochs**	**Wild ass**	**Hare**
Number of bones	2	2	23	4	19	25	1	1	4
Min. number of individuals	2	2	3	2	5	5	1	1	2

Table 2. Distribution of wild mammals from the Neolithic sample according to the number of bones and the number of individuals.

is also a proof for husbandry advanced for its time. Further, it is possible to have (spontaneous) crossbreeding with local aurochs. The recent studies on ancient-DNA do not exclude the possibility for independent domestication events followed by a second wave of parallel dissemination of cattle herds via the Mediterranean route (Hristov et al. 2017).

The calculated sheep height is 59cm on average, characteristic of the primitive small Neolithic sheep. The domestic pig is also very small (as demonstrated by the bones of three individuals) and varies from 56 to 72cm (the height of the recent Eastern Balkan primitive breed is 70 to 80cm).

Wild Mammals

Regardless of the small number of individuals of wild animals, the recorded species are numerous (*table 2*). As expected, the wild boar is among the species with the maximum number of bones. Usually, boar and red deer are the main game animals, found at prehistoric sites on the Balkans (Спасов/Попов 2007). The scarce occurrence of the red deer is one of the characteristic features of this site, distinguishing it from most of the other sites in the country. Perhaps this could be explained by the very high percentage of fallow deer and roe deer (which usually are underrepresented in prehistoric sites). This indicates specific, likely forest-steppe and poor of snow biotopes, characteristic at that time for the southern Black Sea coast. Studies in recent years show with certainty that fallow deer is an autochthonous species which has disappeared from the country in later ages and which, owing to natural causes, has been distributed mainly in south-eastern Bulgaria (Spassov/Iliev 1994; Спасов/Попов 2007).

Of interest is the finding of a metacarpus of *Equus hydruntinus* (European wild ass), an indicator of open spaces. This species is a relict species from the Pleistocene, too scantily distributed in Europe during the Holocene, rare also for our country, although Bulgaria is one of the few areas where this wild *Equidae* has existed at that time. Chernomorets is the southernmost point of distribution of the species on the Balkans in the Holocene. The last representatives of this species in the country, and thus in Europe and around the world have been established in the Chalcolithic of Durankulak (Spassov/Iliev 2002).

Pit 50A

A total of 707 bone remains have been provided for processing, of which approximately 80% or 570 pieces are identifiable to species level. The bones have been deliberately broken and bear traces of human activity. A fragment of an antler of roe deer appears to have been used as a tool for digging.

The bone fragments are generally larger (not crushed to such small pieces as the bone remains from the Neolithic and Chalcolithic layers of Akladi Cheiri), as demonstrated for example from some well-preserved horn and cranial remains of bovids and aurochs.

Species composition and the ratio of domestic to wild animals according to the identifiable bones: 96.84% domestic to 3.165% wild animals according to the number of bones. The prevalence of domestic animals is very strong.

Among the domestic forms cattle, sheep/goat (among these bones are identified for sure remains of a goat), domestic swine and dog have been identified.

In terms of numbers of bones, the most numerous are cattle, with 312 bone fragments belonging to a minimum of nine to ten individuals; but according to the number of individuals most numerous are the small ruminants with 135 remains belonging to a minimum of 20 individuals. Pig is surprisingly well represented with about 70 bones which belong to a minimum of about eight or nine individuals; dog is represented by 20 bones possibly of three individuals.

From the wild species, roe deer with seven bones of probably four individuals; red deer (four bones of probably one individual); aurochs (three bone remains of two individuals) and wild boar (one bone) are recorded. Three bone remains of wild birds were found (identified by Prof. Z. Boev).

Osteometric Characteristics of some Wild and Domestic Animals: Bull's Horn, Core Remains (*pr. cornuales*)

Skull of ox (bull):
- Greater occipital height: 156.5mm
- Small occipital height: 117mm
- Width of *foramen magnum*: 40.5mm
- Height of *foramen magnum*: 42.5mm
- Circumference of left horn-core base: 2.75mm
- Intercornual line: 172.5mm
- Large frontal width: 262mm
- Greatest occipital width: 152mm
- Smallest occipital width: 132mm

The shape of the intercornual line indicates the features of the *brachyceros*/*primigenius* crossbreeds (according to the criteria related to the modern cattle typology). At the same time the intercornual line, as well as the size are closer to the to the *primigenius* type.

The height of the ox at the withers is calculated after the metatarsus to 120.38cm and the metacarpus to 127.20cm, respectively, by using the combined method of Атанасов et al. (1980). The average calculated height is approximately 124cm, confirming the above results.

Aurochs (*Bos primigenius*), *pr. cornualis*:
- Circumference of the base: 320.5mm
- Big diameter of the base: 118.5mm
- Small diameter of the base: 85mm
- 2/3 in % = 71.73: bull

Pit 56

Domestic Mammals

A total of 236 cattle bones have been identified. They show no differences with the previous material (average height of about 120cm, similar to the grey Iskar cattle, a local breed, from the group of the *brachyceros/primigenius* crossbreeds).

Bone remains of small ruminants, among which sheep (predominant) as well as goat are identified, are more abundant in this structure with 417 pieces. It is not clear whether it is a kind of food 'selection' or a matter of accidental accumulation in this bone sample. Even though in this way these small ruminants generally begin to dominate the Neolithic layer of this site, this result does not change what was said above about the high percentage of bovine remains in the Neolithic sample, which indicates well developed stock breeding. Sheep have an average height of approximately 61cm, which confirms the conclusion made earlier: a typical small and primitive breed is present. The height is similar to that of sheep from several Bulgarian Prehistoric sites such as Golyamo Delchevo, Ezero and Ovcharovo and to that of the local primitive breed called *tsakel*. Based on seven third lower molars we could conclude that sheep are slaughtered mostly between two and four years of age.

Third, as usual, according to the number of remains is the domestic pig with 37 bones.

Wild Mammals

Wild animals represented by only single bones are: wild boar, red deer, fallow deer, roe deer, aurochs, fox, hare, or a total of 13 bones. In addition, relatively many bones of wild birds occur: 35 remains (heron, common coot, geese, Golden Eagle and others. Identified by Prof. Z. Boev) were found, as well as a number of fish remains (18 bones).

The cutting of the carcass was done using the longitudinal method of slashing (determined in several cervical vertebrae of sheep and bovids), which is still practiced nowadays.

Chalcolithic

Characteristics of the Bone Sample: Traces of Human Activities

This study is based on a sample of 2531 bones presented for processing in 2009. To the species level, 2058 bone remains have been identified. The material consists of bones and bone fragments of domestic and wild mammals, hunting birds, fish and bivalve shells.

The bones are highly shredded, whole preserved bones in the material are rare: almost all bones are transversely or longitudinally crushed or slashed in order to be easily used for culinary processing or for the removal of bone marrow; usually skulls are finely chopped and mandibles are slashed in the sagittal plane. Charred and blackened bones were found. Individual vertebrae bear traces of cross-cutting, indicating transverse butchering of separate corpse parts. Numerous bones, most often belonging to young animals, have traces of biting by dogs. These characteristics determine the bone sample as 'kitchen middens'.

The most common bone remains are of mandibles and of teeth, *vertebrae*, *costae*, *humeri*, *tibiae*, *metapodials* and, to a certain extent, *tali*. This finding is not surprising (as well as for the Neolithic sample) as these are the most numerous bones of the skeleton or the most difficult remains to be destroyed in taphonomic context. The smaller number of second and especially third phalanges compared with the first, at least in part can be explained by the way of skinning, whereby distal phalanges are likely to remain in the skin.

The Ratio of Wild Animals to Domestic Animals and the Role of Husbandry and Hunting

Owing to the large number of remains of domestic animals, the calculated number of individuals following the method of Bökönyi (1970) corresponds rather to the minimum number of individuals, while that of the wild animals (due to the small number of remains) rather to the approximate number of individuals. Therefore, we believe that comparing bones based on the number of individuals in this case is unreliable. That is why the comparison between domestic and wild mammals in this paper is based mostly on the number of bones rather than on the number of individuals (see above).

Wild mammals, and above all the remains of birds, fish and mussels represent an insignificant part of the total number of remains (bone remains of domestic mammals: 1916; bone remains of wild mammals: 129). In this respect, there are similarities with the findings for the bone sample from the Late Neolithic Period. The village relied on a developed animal husbandry, while hunting and gathering represented only additional means of livelihood. Hunting skills were perhaps linked to the activities of individual, specialised hunters. Proof of this is the very rich composition of species of wild mammals and birds.

Given the species composition of wildlife, the small number of remains and at the same time the wide variety of wild species, we could assume that hunting was not so much related to the satisfying of nutritional needs, but instead to provide trophies, hides and perhaps even to the protection of domestic herds and the village itself from predators (it reflects in some cases the so-called predator/human conflict).

Domestic Mammals

The statistic distribution of domestic animals according to the number of remains is logical. Cattle (*table 3*) and small ruminants are the most numerous, similarly to the Neolithic sample, followed by pigs and finally by dogs (*table 4*). In terms of bone number cattle prevail, while the estimated number of individuals of small ruminants is slightly larger than the one of cattle, but it is possible that it is artificially increased. Therefore, we can assume that the ratio of cattle and small ruminants is approximately the same, perhaps with a slight preponderance for cattle. In any case, the high percentage of cattle remains is a sign of a developed

	Ox-horn-core remains (*pr. cornuales*)					
Big diameter of the base	88	88	56	54	55	48
Small diameter of the base	67.5	64	44	49	39	39
1/2 in %	76.13	72.31	78.57	98.24	70.70	81.54
Sex	Bull	Bull	Bull	Cow	Bull	Cow

Table. 3. Osteometric characteristics of ox horn-core remains from pit 50A.

	Domestic mammals					
	Cattle	**Sheep/Goat**	**Sheep**	**Goat**	**Swine**	**Dog**
Number of bones	992	665	35	43	159	22
Min. number of individuals	36	28	6	7	15	4–5

Table. 4. Distribution of domestic mammals from the Chalcolithic sample according to the number of bones and the number of individuals.

farming for its time. The third place of the pig is typical of most prehistoric sites (an exception is the bone sample from the settlement of Ovcharovo where pig dominates small ruminants). As in other prehistoric sites, the dog is the least common in term of bone remains.

The heights of oxen at the withers and the presence of cattle with the height of *primigenius* individuals, 'crossbreed' individuals (according to size) and *brachyceros* individuals (after the criteria related to the modern cattle typology) are established from a number of bones: *astragali*, *calcanei*, *metapodials* and *phalanges*. The result is similar to those of other prehistoric sites we have studied, and is virtually identical to that of the Late Neolithic sample from Akladi Cheiri. The calculated height of cattle varies widely: 106.77 to 145.04cm and the proportion of animals with the height of *brachyceros*, 'crossbreed' or *primigenius* type (in %) is 17.24/32.76/50, correspondingly. The average bovid height is similar to that of recent crossbreeds but with a predominance of specimens with higher individual size. The wide range of height variations, typical also of the Neolithic sample from the site and for a number of other sites we have studied, indicates breeding of still unconsolidated breed. The presence of even primitive breeding activity for the consolidation of size could be assumed. It is not impossible (see also the chapter on the Neolithic) that also free growing cows could have been inseminated by aurochs, which might affect the increase in height.

The ratio between the number of sheep and goats, according to the number of identified specimens is almost equal. The height of goat calculated based on separate *metacarpi* is estimated to be approximately 66 to 67cm and fits the data from other Neolithic and Chalcolithic sites in Bulgaria: 59/64/71cm (the height of modern local breed is between 70 and 80cm).

The height of domestic pig is calculated using the astragali and calcanei and is 71 to 75cm (it was noted above for comparison, that the primitive local East Balkan pig varies between 70 and 80cm).

Age Composition of the Flocks

The large number of jaws and teeth allow calculating the age at which the animals are slaughtered for food. These calculations provided the following data:

Ox

- juvenile (up to 1 year) 13%
- subadult (1 to 5 years) 57%
- mature (5 to 10 years) 26%
- old (over 10 years) 4%

	Wild mammals											
	Fox	**Wild cat**	**Lion**	**Wild boar**	**Red deer**	**Fallow deer**	**Roe deer**	**Aur-ochs**	**Wild horse**	**Wild ass**	**Hare**	**Bottle-nose dolphin**
Number of bones	1	2	1	8	21	55	19	5	1	1	15	1
MNI	1	2	1	2	3	6–7	3	1	1	1	3	1

Table. 5. Distribution of wild mammals from the Chalcolithic sample according to the number of bones and the min. number of individuals (MNI).

Sheep/Goat
- up to six months 24%
- from 6 months up to 2 years 8%
- 2 to 6 years 63%
- over 6 years 5%

Domestic Pig
- juveniles (up to 6 months) 9%
- subadults (6 months up to 2 years) 43%
- mature (2 to 5 years old) 1%
- old (over 5 years) 7%

Such an age composition indicates certain preferences and the existence of breeding activities in order to obtain maximum and comprehensive production of meat and hides (cattle and pig), and milk and wool (sheep and goat).

Wild Mammals

The species composition of wild animals is particularly diverse (*table 5*). The presence of the bottlenose dolphin is not surprising since this species often prefers coastal waters. As in the Neolithic sample, representatives of the family of the deer (fallow deer, roe deer and red deer) are the most numerous. Noteworthy is the strong presence of the autochthonous population of the fallow deer, which is still a very common and hunted species. This suggests that the conditions for its existence are particularly suitable.

The combination of aurochs, wild horse, wild ass and fallow deer suggests the presence of vast open spaces, likely manifested as a mosaic of forests, steppe regions and sparse forests.

Of particular interest are the findings of wild horse, wild ass and of lion. The wild horse and the wild ass *Equus hydruntinus* (its latest registered presence in the world together with its finding at the Durankulak site [see Spassov/Iliev 2002]) confirm the availability of open spaces as it was during the Neolithic Age. The wild ass, found also in the Neolithic sample, confirms the lasting though astonishing presence of this species so far south on the Balkans.



Fig. 1. Calcaneus of a lion (*Panthera leo*) from Akladi Cheiri. Total length 111.3mm.

The wild horse, which has been identified after a molar, bears the features of *Equus germanicus*, the broad-hoofed horse typical for the Pleistocene, that has survived (according to our data) to the Holocene, co-inhabiting together with *Equus ferus* (Spassov/Iliev 1997; 1998).

The lion (*Panthera leo*) is recorded based on the presence of a *calcaneus* (*fig. 1*). The *calcaneus* is very large (max. width 53.3mm, max. length 111.3mm) and possess the typical felid features (Громова 1960), such as the coracoid facet morphology (undivided in two parts by a transversal ridge), the lack of a longitudinal crest on the anterior dorsal surface of the lower bone portion and the rounded sustentacular facet. The *calcaneus* shows the features of the lion noted by Громова (1960, see fig. 17) that differentiate this species

from the tiger, as well as from the cave lion (*Panthera spelaea*): the convex (not oblique) lateral contour of the lower proximal portion (under the coracoid facet) in dorsal view; the dorsally bulged lower extremity of the dorsal surface of the proximal portion (seen in lateral and medial view), the rounded and not quite oblique lower surface of the bone (the cuboid facet), the smooth and poorly developed (slightly visible) transversal ridge on the dorsal surface of *tuber calcanei*. The comparison of the *calcaneus* from Akladi Cheiri with those of recent lions and large Siberian tigers (see also Громова 1960) indicates that this prehistoric individual exceeds considerably the average size for the recent African population. The size and proportions of the bone from Chernomorets give ground to suppose, after a comparison with zoo lions and tigers with known weight, that this bone belonged to a very large adult male that exceeded 200kg. For comparison, the weight of the adult male African lion varies as follows: the average weight is about 180kg; an extreme weight of 272kg is recorded near Mount Kenya (Nowell/Jackson 1996, 17–21). The presence of lion is not surprising given the numerous ungulates and the environment described above. Evidence to date indicates that the Chalcolithic period is the time of maximum distribution of the species in Bulgaria and generally in south-eastern Europe, where it spread and lived (on the Balkans) until about 2000 years ago. On the Bulgarian coast of the Black Sea, the lion was very common at that time and is known from Golyamo Delchevo (Varna Region), Durankulak and from two different archaeological sites (Akladi Cheiri included) near Sozopol. In south-eastern Europe, the lion must have arrived at the very beginning of the Holocene, well after the disappearance of the so-called cave lion. This should have happened along two pathways of distribution: along the Bosporus, before its opening, into the Balkans, reaching Serbia in the west and through Transcaucasia to the north along the northern Black Sea towards Ukraine and Hungary (Spassov/Iliev 1994; Спасов/Попов 2007; Bartosiewicz 2009).

The remains of wild mammals from the site provide new, up to now unknown, data about the diversity of Bulgarian and Balkan fauna from the end of the first half of the Holocene and show an extraordinary richness of the Black Sea Region at the time.

Additional Material

Analysis of supplementary additional bone material (1251 bone remains from which 285 are unidentifiable) evicted in 2009 from the Chalcolithic level gives the following results:

Domestic Animals

A total of 434 new bovine remains are established from a minimum of 18 individuals, as well as 384 remains of sheep/goat belonging to a minimum of 30 individuals. Once again, the number of cattle bones prevails and the estimated number of individuals of small ruminants is larger, but it can be assumed that it is a bit inflated. Overall, bovids and small ruminants share the first place. A final conclusion could be drawn that small ruminants are probably a little more numerous, but cattle breeding is very well developed. In addition, 58 remains of domestic pig and 18 of dog were identified. As a whole, the remains of dogs on site are numerous, as compared to many other sites.

Wild Animals

With 72 fragments their remains again are scarce, including bird bones and mussel shells. Aurochs is represented with two bones, wild boar with twelve bones, fallow deer is again predominant with 27 bones, red deer recorded with nine bones, roe deer with twelve bones, hare by six bones, fox by three bones, stone marten by one mandible (the stone marten is a new species for this site, complementing the varied sample of game species).

Early Bronze Age

Pit 23

Bone remains are few: 57 fragments of which 11 are indeterminable.

Species composition. All bones of mammals belong to domestic animals, which distinguishes the content of Pit 23 from that of Pit 50A. However, among the findings are also single shells of the common Black Sea mussel and one vertebra of a fish.

Cattle are again represented with the most numerous bone remains, but they seem to belong to two individuals only. Small ruminants (sheep/goat) are represented with 19 bone fragments from three individuals (approximate number of individuals), domestic pig with two bones from one individual and dog with three bones probably belonging to one individual.

Some General Conclusions

The remains of prehistoric (from the Late Neolithic to the Early Bronze Age) animal bones from Akladi Cheiri, Sozopol Region bear the marks of the so-called kitchen middens. Among them, the remains of domestic animals prevail significantly. Stock farming has been more widely practiced than hunting as a source of nutrition. There are also some signs of breeding activities: in all samples, cattle remains are predominant to a certain degree, indicating economic activities developed for their time (especially for the Neolithic). The average bovine height, which is from an unconsolidated breed (about 120 to 121cm), is generally close to that of other Neolithic and Chalcolithic sites in Bulgaria. Dominant are the larger individuals, which may be due to attempts for primitive selection or spontaneous crossbreeds with local aurochs. Based on the average age of slaughtering (according to data from the Chalcolithic period) individual age preferences for different animals in order to obtain maximum and comprehensive production of meat and hides (cattle and pig), milk and wool (sheep and goat) are identified.

The remains of wild animals are few but refer to a large number of species. As expected, the remains of *artiodactyls* prevail, for instance of fallow deer, roe deer, wild boar and red deer. The dominant amount of bones belonging to fallow deer in comparison to those of red deer is a peculiar feature which demonstrates the strong presence of fallow deer in the typical biotopes of southeastern Bulgaria during the Neolithic and Chalcolithic. Along with the Chalcolithic of Durankulak, the Chalcolithic of Akladi Cheiri shows the last record of the so-called European wild ass *Equus hydruntinus*. The high density of the indigenous fallow deer, the presence of two species of equids, of the aurochs and the lion, all of which have disappeared from the modern fauna of Bulgaria and Europe, and most from the global fauna, suggests a very high biomass productivity of the biocenosis at this time, as well as an extremely rich biodiversity of the region during the Early and Middle Holocene. Based on the ecological requirements of the species, this rich mammal fauna has existed in mosaic natural landscapes of forest and open (steppe and shrubby) areas in which the latter were sufficiently large and well represented.

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Elena Marinova

Wood Constructional Elements and Archaeobotanical Evidence from the Late Neolithic to Early Chalcolithic Well of Akladi Cheiri, South-Eastern Bulgaria

Keywords: archaeobotany, waterlogged plant remains, Early Chalcolithic, Bulgaria

Introduction

The Late Neolithic (or the transitional to Early Chalcolithic) level of the site Alkadi Cheiri, simultaneous with the Karanovo IV period (5200–4900 BC) in Thrace, yielded a large number of negative features (mostly pits) and a couple of positive contexts, which were identified as compact areas of burnt house remains. The pits have oval or circular mouths and are up to 1.50m deep. They contain deposited material, mostly broken pots and a small number of artefacts. Of special interest for the archaeobotanical research is the pit that dates to the end of the Neolithic and could be interpreted as a well. Thanks to the water logged conservation, wells provide a variety of information otherwise impossible to be detected about cultural and wild plant spectra from the periods of their use and particularly their abandonment (Kreuz 1997). The lower part of the Late Neolithic well discussed here yielded more than two hundred pieces of well-preserved wood, which seem to be mostly part of the wooden construction as well as wood used for other purposes during the existence of the well. The good organic preservation provided also some information on wood working as the majority of the wood fragments contained traces of such activities. Of interest are the plant macroremains preserved in the well's sediments. Therefore, also bulk sediment samples for flotation were obtained and processed. The current paper presents the botanical analysis of this structure which showed rather exceptional for the study region organic preservation. The study will attempt also to draw a picture on the natural and anthropogenic vegetation as recorded in the well sediments. Although comparable structures were found at other more or less contemporary sites in the study area (P. Leshtakov, pers. communication) due to the efforts of the excavation team working on the site Akaldi Cheiri for first time a systematic sampling, extraction and analysis of the botanical remains was conducted.

Materials and Methods

The excavated well had a circular mouth with a diameter of 1.30m, and its bigger part is situated below the present sea level. It was excavated to a depth of 5.40m and the bottom was not reached (*fig. 1*). The archaeobotanical finds were preserved under constant presence of water (water logging) a kind of preservation which is quite rare and untypical for the study region (Marinova 2006; Kreuz/Marinova 2017). The preservation conditions of the cultural layers common for south-eastern Europe are those of dry mineral soils and therefore only plant remains in charred state (not prone to decay) could be found. The charred plant remains occur only when they get into contact with fire and in such conditions only more compact plant tissues get conserved, while the waterlogged conditions allow much more



Fig. 1. View on Late Neolithic well during its excavation.

variable organic matter and finer plant tissues to remain undamaged in the corresponding sediments. This means that all of the plant material which was imbedded in the waterlogged sediment of the well will be preserved and also will deliver much wider information on vegetation and its use during the period of function of the waterlogged structure (Knörzer 1984; Zerl/Herbig 2012).

Wood

For the current study a subsample of 136 waterlogged wood fragments with a size bigger than 0.5cm were taken for detailed laboratory analysis. The wood fragments analysed were selected with the purpose to obtain the most representative picture possible on the different sizes and shape of wood preserved in the well. The fragments were classified according to their size, shape and whether they were worked or not. From each of the fragments thin sections in transversal, radial and tangential view were obtained and observed under light microscope (magnification 100–400x) in order to obtain taxonomic identification of the different specimens. For the identification the corresponding specialised literature (Schweingruber 1990; Gale/Cutler 2000) and the reference collection was used.

A further part of the wood fragments (n=23) was selected for dendrochronological analysis.[1] In order to obtain additional age control of the wood finds, from the sample with the biggest number of tree rings the inner most and outer most rings were sampled. The distance between the two samples are 60 tree rings. The samples were sent for radiocarbon dating to the 'Center for Applied Isotope Studies' at the University of Georgia. The obtained results were calibrated with the OxCal v4.3.1 program (Bronk Ramsey 2009).

Other Plant Macroremains

A bulk sediment sample of ca. 20l was obtained from the sediments of the well and processed by manual flotation. The plant remains were collected in a fine sieve with a mesh size of 0.3mm and identified under low magnification (6-40x) microscope (binocular). For identification both a reference collection of modern seeds and corresponding literature (Cappers et al. 2006) were used.

1 The dendrochronological analyses were performed in the dendrochronological laboratory of the German Archaeological Institute with the kind participation and support of Dr. Karl-Uwe Heußner.



Fig. 2. Wood fragments from the well infill. Wooden objects with rectangular shape, mostly identified as belonging to oak. Detail view of rectangular wood fragment (bottom) and rounded worked wooden object (top).

Results and Discussion

The wood fragments displayed generally good preservation. Some of them bore traces of woodworking. Before the laboratory analysis the wood fragments were sorted according to their shape and size into the following groups:

(1) Fragments with a length of ca. 10 to 30cm and a thickness up to 6 to 10cm, with more or less rectangular shape: parts of the well construction or other probably architectural elements.
(2) Smaller fragments with a length between 5 and 10cm with various shapes and traces of working (rounded, with grooves, notches, etc.).
(3) Small fragments with a length between ca. 0.5 and 15cm with well-preserved bark or bark fragments. Some of them carry possible traces of working, however the majority seems to be unprocessed.

Seven fragments of quite bad preservation, being very soft and partly damaged were excluded for further laboratory analyses. The wood anatomical study of the remaining fragments revealed a domination of oak (*Quercus* sp.), n=72. Nearly all of the bigger fragments from size group 1 as well as those with rectangular shape from group 2 were identified as oak. The majority of bigger rectangular fragments (*fig. 2*) belonged most probably to the wooden construction of the well. From this construction also the samples taken for dendrochronological analysis originate. However, this analysis has shown that the size and number of rings preserved in all of the fragments provided for study was insufficient to obtain a reliable dendrochronological synchronisation, moreover no local oak chronology is available until present for the time period to which the wood finds possibly belong. The radiocarbon dating of the wood fragment with the longest year-ring sequence revealed a date of 5990±25 BP (UGAMS 13886) for the innermost ring and 5910±25 BP (UGAMS 13885) for the outermost ring. The calibration of both samples using OxCal (Bronk Ramsey 2009) revealed a time range fitting well to the Early Chalcolithic age of the structure obtained through analysis of the archaeological finds (Krauss et al., this volume, 177–184). The date for the outermost sample provides an age between 4830 and 4770 BC (1σ) resp.

between 4850 and 4730 BC (2σ) indicating the *terminus post quem* time point when the well was built.

Besides oak the next frequent wood is maple (*Acer* sp.) with 43 fragments in total. The majority of the possible wooden objects (twelve items out of 19) (for example the shown one on *fig. 2*, above left) were made from maple wood. The maple has durable wood with good qualities for making various objects and is preferred for producing items applied for culinary purposes, tools or furniture (Gale/Cutler 2000).

Further wood identifications revealed the presence of ash (*Fraxinus* sp.) – n=11, cornel (*Cornus* sp.) – n=9, elm (*Ulmus* sp.) – n=3, and alder (*Alnus* sp.) – n=2.

The wood from group 3 showed the greatest taxonomic diversity, as all of the identified tree species were present here. Most probably they correspond to twigs from the natural woodland vegetation growing around the well. It cannot be excluded that some of those wood fragments also originate from human activities which took place near the well.

Apart of wood also other plant macrofossils were extracted from the sediments of the well. Those plant remains are preserved in both waterlogged and charred state. The organic remains show very good preservation and apart of plant remains also small animal bones, insect remains and molluscs were found. A few spherical objects, with shiny surface and very high weight, resembling remains of metal slags were also recorded. According to an analysis of the objects in the CEZA Mannheim, these are concretions that originate naturally from the groundwater.

The most numerous archaeobotanical finds from the flotation sample were chaff remains of hulled wheats, among them the spikelet forks of einkorn (*Triticum monococcum*, n=47) are predominant, while the others like emmer (*Triticum dicoccum*) and a new wheat type are just minor components. The rest of the identifiable chaff remains are fragmented glume bases (n=128) and can be identified as belonging to hulled wheat only. Most probably those finds are by-products from the processing of the cereal crops and more specifically from its stage involving threshing in order to release the enclosed in the chaff grains and make them suitable for food preparation and consumption. While the grains were consumed the chaff was apparently discarded and part of it was preserved in the sediments deposited inside the well. Much more infrequent are the finds of wheat grains (n=7), all preserved in charred state. Further indication of cereal grains are the subfossil preserved wheat pericarps. Further cultivated plants identified in the samples are barley (*Hordeum vulgare*), bitter vetch (*Vicia ervilia*), and flax (*Linum usitatissimum*).

The natural vegetation was represented by small twigs and buds, the last belonging mostly to oak (n=28) but also some single buds of hazel, alder and ash were found. Several fragments of seeds of apple (*Malus* sp.), raspberry/blackberry (*Rubus* sp.) and physalis (*Physalis alkekengi*) reflect wild plants useful for human consumption. The archaeobotanical finds show also a certain variety of open vegetation. Most of those plants are favoured in their distribution by human activities and most probably originate from the human influenced habitats in the surrounding like cultivated fields (*Bromus sterilis*/*tectorum*, *Lapsana communis*), edges of roads, pasture land and waste places (*Plantago major*/*media*, *Polygonum aviculare*, *Setaria verticillata*/*viridis*, *Urtica dioica*), but also partly from wet or humid habitats (*Carex* sp., *Mentha* sp., *Polygonum lapatifolium*, *Verbena officinalis*) which could be developed near the well. The find of *Theucrium* cf. *chamaedrys*, an element of the oak forest undergrowth, indicates the development of oak forests with open character (Bondev 1991).

Conclusions

The studied plant remains from the Late Neolithic to Early Chalcolithic well from Akladi Cheiri provides plenty of information on the use of the plant resources and natural vegetation developed in the area during the existence of the well.

The wooden construction of the well is composed by oak beams, most of the wooden objects found were made from maple wood.

The main cereal crops (hulled wheats) typical for the period are also represented in the sediments taken for archaeobotanical analysis from the well. They are recorded mainly through by-products of their processing – chaff fragments. The waterlogged well sediments provided also diverse information on the local vegetation developed near the well and the existence of a variety of habitats like open oak forests, pasture and grassland, wet meadows, etc.

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Absolute Chronology of the Excavated Features at Akladi Cheiri and the Beginning of Copper Metallurgy in the Eastern Balkans

Keywords: radiocarbon chronology, dendrochronology, Late Neolithic, Chalcolithic, early copper metallurgy

The site of Akladi Cheiri yielded in its excavated areas features from various prehistoric periods. Since only a few of them show stratigraphic overlaps, the relative chronological determination was made mainly on the basis of the material found in them. The features are distributed over the periods from the Late Neolithic to the end of the Early Bronze Age. Within this time range they concentrate in the Late Neolithic, Early Chalcolithic and Late Chalcolithic periods, according to the Bulgarian terminology. During the Final Chalcolithic a few burials were dug at the site (Лещаков/Класнаков 2009; Cholakov/Chukalev 2010, 735 f.).

Samples of animal bones were taken for AMS dating from pits assigned to different periods (features 1, 50, 50A, 52, 54 and 64), including from a deep well-shaft (feature 50A, more than 5m deep) assigned to the Early Chalcolithic. Six of these samples were processed at the Lyon Radiocarbon laboratory and measured at the Commissariat à l'énergie atomique et aux énergies alternatives (CEA) facilities at Saclay. Together with them two human bones from the Final Chalcolithic grave 1 were measured. This data series, produced in the frame of the French National Research Agency (ANR) project 'Balkans 4000' coordinated by Z. Tsirtsoni in 2008–2011, was compiled and briefly commented in the project's final publication (Tsirtsoni 2016b). Another animal bone, from pit 28, was measured with AMS in the Klaus-Tschira Laboratory in Mannheim. This feature is of particular importance because of its archaeometallurgical installations.

Further dates were obtained from the wood pieces found in the well-shaft 50A. The lower part of this shaft contained indeed hundreds of pieces of waterlogged wood, belonging to various tree species (oak, sycamore, ash, elm tree, and others). The nature of the botanical species represented, the size of the pieces and the presence of traces of woodworking on several of them indicate that these were building material, possibly coming from some sort of platform associated with the use of the well. Efforts for a dendrochronological determination of selected wood pieces at the dendrochronological laboratory of the Department for Natural Science of the German Archaeological Institute in Berlin did not prove successful, as all samples were small and moderately preserved. According to Dr. Karl-Uwe Heußner who conducted the study, the number of tree rings of the vast majority of pieces was not sufficient for a secure dendrochronological matching, especially since no local chronology is available and the expected time frame would have been very vague. But one of the oak pieces preserved enough rings (60) to attempt radiocarbon dating of its innermost and outermost rings and wiggle-matching. The measurement was made at the University of Georgia Centre for Applied Isotope Studies with the AMS method. Another piece of timber, with 30 rings, was measured with the conventional Gas Proportional Counting method at the Laboratory of

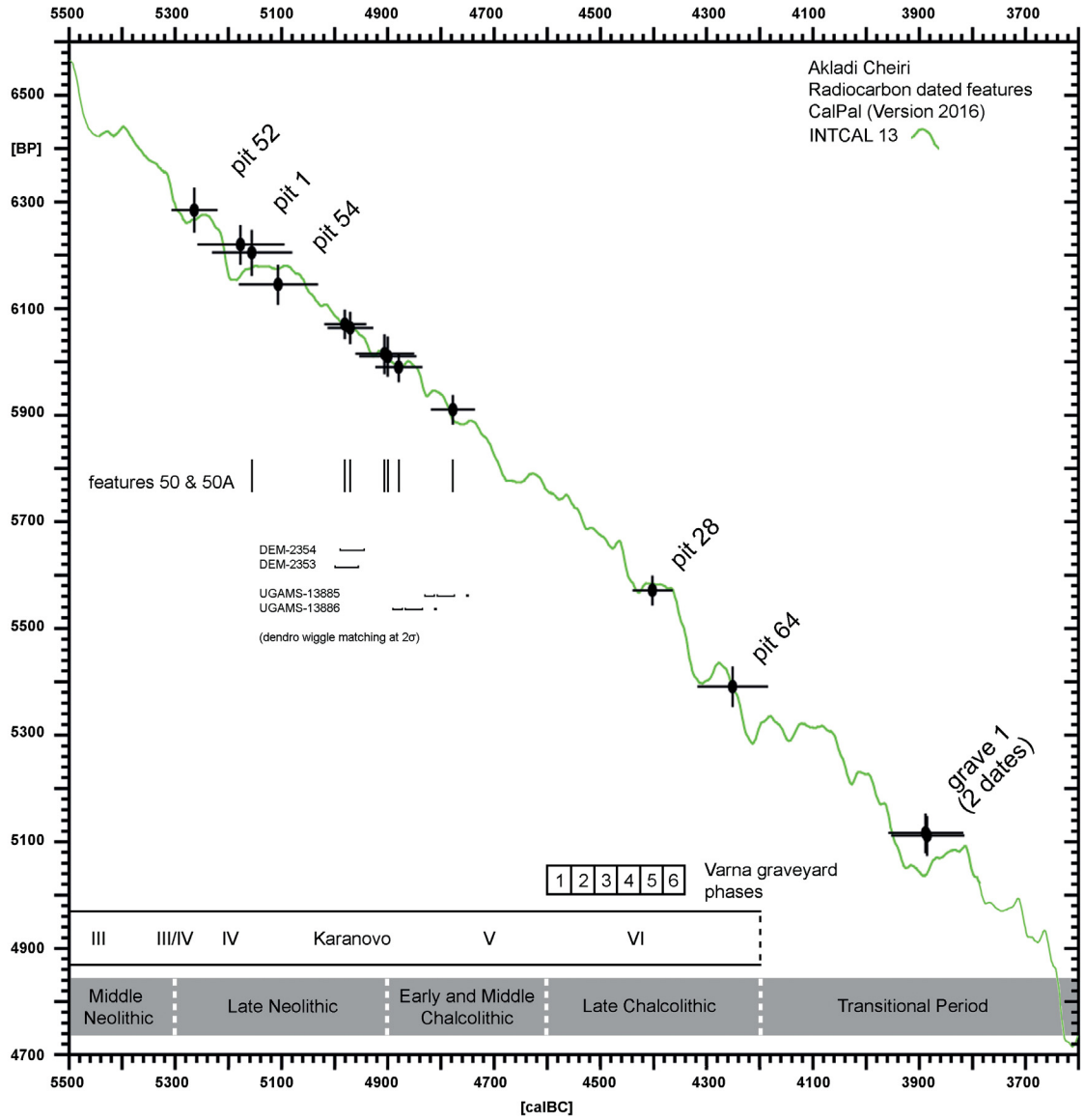

Fig. 1. Calibration of radiocarbon dates from Akladi Cheiri (*table 1*) on the calibration curve INTCAL13 with the Program CalPal (version 2016). From feature 50/50A, the values are given according to the dendrochronological wiggle matching (see *figs. 3* and *4*). For comparison in the lower panel the phasing of the Varna necropolis (see Krauß et al. 2016), of tell Karanovo (see Krauß 2008), and the traditional chronology of Bulgarian prehistory (cf. Görsdorf/Bojažiev 1996).

Archaeometry of the National Centre of Scientific Research 'Demokritos' in Athens.

Thus, we display altogether fourteen ^{14}C-dates from seven different contexts for Akladi Cheiri (*table 1*). All dates are age-calibrated using the calibration curve INTCAL13, at 2σ (probability 95%). Using the CalPal (version 2016) graphics export in postscript format, we obtain a graphical combination of the different calibration results (*fig. 1*).

The radiocarbon dates from pits 1, 52, and 54, line up according to the expected archaeological order and cluster in a range approximately between 5300–5000 calBC, providing evidence of a continuous occupation of Akladi Cheiri during the Late Neolithic. Although pit 54 was assigned initially to the Early Chalcolithic, the related date Lyon-7488, with a calibrated value of 5211–5000 calBC, is still clearly in the range of the Late Neolithic. Finds of various minerals such as malachite, limonite, and hematite from pit 52 indicate that already since the 53rd cent. BC these colourful stones had been collected. They might have served

Lab Code	Age BP	STD (±)	Sample n°	Context	Type of dated event	Depth	Material	calBC Date (95%)
Lyon-7490/SacA-21378	6285	40	2009-11	Pit 52	Fill	0–1.40m	Animal bone	5365–5207
Lyon-7485/SacA-21373	6220	35	2009-5	Pit 1	Fill	0.70m	Animal bone	5301–5060
Lyon-7488/SacA-21376	6145	35	2009-8	Pit 54; pit with copper awl	Fill		Animal bone	5211–5000
DEM-2352	6205	40	2013-01a	Pit 50A (well with remains of wooden structure); 10 innermost rings of piece of wood 2013-01	Approximate start of tree A life		Wood (probably oak)	5296–5051
DEM-2353	6071	25	2013-01b	Pit 50A (well); 10 middle rings of piece of wood 2013-01	Tree A growth		Wood (probably oak)	5051–4909
DEM-2354	6064	28	2013-01c	Pit 50A (well); 10 outermost rings of piece of wood 2013-01	Tree A growth; terminus post quem for the cutting		Wood (probably oak)	5052–4852
UGAMS-13886	5990	25	2013-14a	Pit 50A (well); inner rings from piece of wood 2013-14	Tree B growth		Wood (oak)	4944–4799
UGAMS-13885	5910	25	2013-14b	Pit 50A (well); outer rings from piece of wood 2013-14	Tree B growth; terminus post quem for its cutting		Wood (oak)	4837–4722
Lyon-7487/SacA-21375	6015	35	2009-7	Pit 50A (well)	Fill of the well, lower part	4–4.20m	Animal bone	5000–4802
Lyon-7486/SacA-21374	6010	35	2009-6	Pit 50 (upper part of pit 50A-well)	Fill of the well, upper part	1.20m	Animal bone	4996–4802
MAMS-35509	5571	25	173a	Pit 28; pit with copper ores and crucible fragments	Fill		Animal bone (Bos)	4454–4356
Lyon-7489/SacA-21377	5390	35	2009-12	Pit 64	Fill	0.50m	Animal bone	4338–4072
Lyon-6027/SacA-15596	5115	35	2008-1	Grave 1	Death of the inhumated person	0.40m	Human bone	3981–3800
Lyon-7484/SacA-21372	5110	35	2009-1	Grave 1	Death of the inhumated person	0.40–0.50m	Human bone	3976–3799

Table 1. List of radiocarbon dates from Akladi Cheiri.



Fig. 2. Section of the sample 2013-01 close to the innermost rings. The curvature indicates that this fragment is close to the centre of the tree.

as raw material for the production of jewellery. The discovery of a small copper awl in pit 54 is however the first clear proof for the plastic shaping of copper in Akladi Cheiri 5. Therefore, by the 50th cent. BC at the latest, copper processing on the site would have been fully developed. Copper metallurgy in the Eastern Balkans thus begins no later than the Late Neolithic, i.e. the period corresponding to the horizon Karanovo IV in the chronocultural sequence of Thrace (Krauß 2008; see also below). This date is in agreement with evidence from other sites in neighbouring areas, e.g. the western Balkans (Radivojević et al. 2010) and the northern Aegean (Koukouli-Chrysanthaki et al. 2007).

The series of ^{14}C-dates from pit 50 and its continuation, the well-shaft 50A, attest to a smooth transition from the Late Neolithic to the Early Chalcolithic, i.e. the period corresponding to the Karanovo V horizon of the Thracian chronocultural sequence (also called 'Marica Culture'). They further suggest that the filling of the well was a uniform and rather rapid event. Indeed, the two dates from animal bones found in the lower and the upper part of the fill, respectively dates Lyon-7487 (5000–4802 calBC) and Lyon-7486 (4996–4802 calBC), are practically identical. The dates obtained from the two pieces of timber collected in the lower part of the well show a slight distance from each other. Fig. 2 shows a section of the sample 2013-01 close to the innermost rings. There were 30 rings and separated in sets of tens. The curvature of the rings indicates clearly that this sample comes from very close to the centre of the tree. The innermost part which was only a few rings away from the centre was rotten and mineralised and finally gave an erroneous date which was not used any further. Thus, the two sets used were the middle and the exterior set separated by ten years difference. According to their dendrochronological distance, the two dates were modelled together and integrated into a wiggle matching curve plot (*fig. 3*). From this treatment it appears that the outermost rings of this particular wood sample, represented by DEM-2354 give a wiggle matched date of 5027–4930 calBC (95.4% probability), with a weighted mean of 4971±24 calBC. As discussed this is by no means close to the felling date but rather close to the beginning of the life of this tree. The wood measured as sample 2013-14 from an oak tree yielded two dates with a dendrochronological distance of 60 years. The outermost rings of this particular wood sample, represented by UGAMS-13885, give a wiggle matched date of 4842–4737 calBC (95.4% probability) with a weighted mean of 4795±27 (*fig. 4*). It is not known how close these rings are with respect to the bark of the tree. Maybe the difference in dates between the two pieces of timber is due precisely to the different parts of trees represented: the first (2013-01) could be from the inner

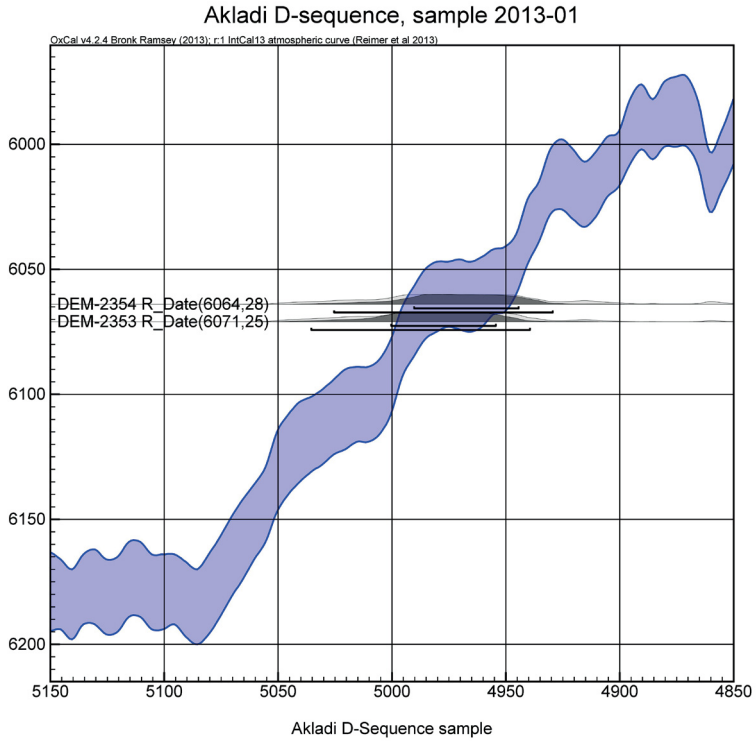

Fig. 3. Wiggle matching curve plot of the pair of rings from sample 2013-01.

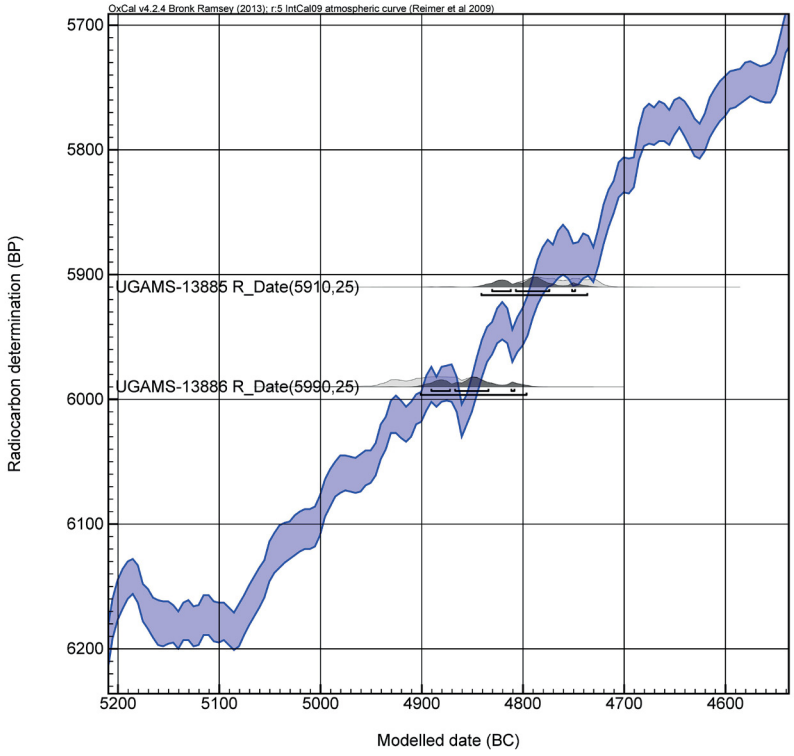

Fig. 4. Wiggle matching curve plot of two ring sets from sample 2013-14. These samples are separated by 60 years (rings).

part of a big tree, whereas the latter (2013-14) could be from an outer/younger part. Considering also the lower values from the bones, the filling of the well should be placed in the years between 4840 and 4800 calBC. There are no metallurgical finds from the well.

These dates help to improve the chronology of the Neolithic–Chalcolithic transition on a broader regional scale. The chronology of those periods in Bulgaria, developed since the 1960s above all on the basis of the stratigraphy of Tell Karanovo in Thrace, is still rather poorly supported by ^{14}C-dates

despite the efforts in recent years. The first series of ^{14}C-dates, measured with the conventional ß-decay technique at the Berlin Radiocarbon Laboratory, had relatively large statistical errors (50 years or more) and were processed on big and thus potentially long-lived and/or reused charred wood samples (Görsdorf/Bojadžiev 1996; Krauß 2008; Tsirtsoni 2016a). The entire Karanovo IV horizon was weakly represented at the eponymous site until the end of the 1990s, when new investigations provided material for a series of AMS dates at the Laboratory of Vienna, with smaller errors (35–40 years BP) but conducted again on charcoal (Hiller/Nikolov 2005). The available dates span the interval between 5280/5200 and 5000/4950 calBC.

A dense data series for the Late Neolithic comes from the site of Aşağı Pınar in the neighbouring area of Turkish Thrace. The corresponding layers Aşağı Pınar 4 and 3 date to the periods between 5300–5050 calBC (2σ) (Görsdorf 2005; both conventional and AMS dates from charcoal and seeds). This time interval is further supported by the datasets produced lately on the sites of Drama-Gerena (Gleser 2011; conventional and AMS dates from bones) and Sarnevo (Cook et al. 2017; AMS dates from teeth and bones), both in the eastern part of the Thracian plain. In the latter site in particular, the lifetime of the Karanovo III/IV settlement has been estimated in the years between 5375–5290 calBC. Thus, the time span for the Karanovo IV horizon could be indeed limited to the interval between approximately 5300–5000 calBC. Considering the evidence from Akladi Cheiri, we can now suggest that the horizon Karanovo V and thus the Bulgarian Early Chalcolithic might have started as early as 5000 BC, and in any case prior to 4850/4800 BC.

The chronologically next feature, pit 28, yielded numerous archaeometallurgical finds. Indeed, from this pit came several pieces of ores and partly slagged ceramics, including an oval crucible with adhering copper globules that indicate melting. The related date MAMS-35509 has a calibrated value of 4454–4356 calBC, which falls into the range of the Bulgarian Late Chalcolithic (corresponding to the Karanovo VI horizon in the Thracian chronocultural sequence). This date is in good agreement with the high dating of the Late Chalcolithic, first established by the data series of the cemetery of Varna (Higham et al. 2007; Krauß et al. 2014; 2016) and further confirmed by the results obtained on other sites in Bulgaria and in neighbouring areas (Borić 2009; Tsirtsoni 2016b; and several papers in Hansen et al. 2015). The date Lyon-7489, from pit 64, is slightly younger, with a calibrated value of 4338–4072 calBC; no metallurgical finds are reported from this feature. Accordingly, the use of pit 28 would be roughly parallel to phases 4 to 6 of the Varna cemetery, whereas pit 64 would be used shortly after the end of it.

The area seems to have remained uninhabited for a long time. At the beginning of the 4th mill. BC a series of inhumations were made at the spot of the previous Late Neolithic–Chalcolithic settlement. The two dates from grave 1 (Lyon-6027 and Lyon-7484) provide an identical calibrated result in the range of 3980–3800 calBC. The position of the inhumation in the grave, supine with knees bended on the side, is typical of the 4th mill. BC (Heyd 2011; Frînculeasa et al. 2015; Kaiser/Winger 2015). Noteworthy among the grave goods are some small pieces of malachite, which testify to the use of ore minerals from Medni Rid in this time. Given the position of the burials and the grave goods, graves 4 and 5 can also be assigned to this horizon. These burials are evidence of human presence in the area at a time when most of the tell settlements in north-eastern Bulgaria and Thrace seem to come to an end (Tsirtsoni 2016b). Whether or not copper ore was extracted for metal production in Medni Rid during those years remains unclear.

For the only feature from the end of the Early Bronze Age, pit 23, there is no absolute date. Its presence proves, however, that activities still took place in the area during the 3rd mill. BC.

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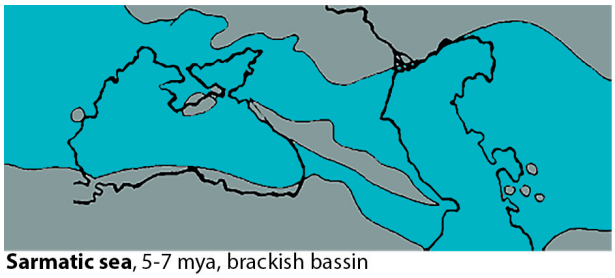
Submerged Prehistoric Settlements along the South Bulgarian Black Sea Coast

Keywords: submerged settlements, Chalcolithic, Bronze Age, sea level changes, western Black Sea coast, copper metallurgy

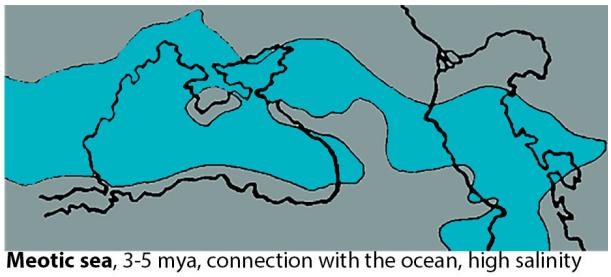
Submerged prehistoric settlements[1] along the Bulgarian southern Black Sea coast should be considered together with other of the archaeological sites that are under water elsewhere along the western coast of the Black Sea. The reasons for similar structures to be discovered below sea level are mainly two: the absolute rise of the sea level and the negative local tectonic movements on land.

During its geological history the Black Sea basin changed its size and shape many times as the coastal zones, inhabited as early as the Palaeolithic, were periodically flooded. It has been supposed that the Black Sea differentiated as a separate pool during the Pliocene (*fig. 1*). This proto-basin was of a significantly larger size than the today's one covering vast areas of the modern mainland. The so-called Chaudin Sea existing during the Early Pleistocene was a semi-salty basin (according to other researchers it was a fresh water basin) of a reduced size which was not connected to the World Ocean. Its formation was a result of a regression during a period of freezing, probably the Mindel glacial. This period lasted about 300,000–400,000 years during which the sea level changed many times. During the Middle Pleistocene the basin increased its level due to climate warming. A connection with the Mediterranean took place resulting in salting the basin water now known as Palaeo-Euxine Sea. The next evolutionary stage was the time of the Riss glacial during which the Uzunlar Sea represented a closed salty basin of a size smaller than today (Попов/Мишев 1974, 221 f.; Димитров et al. 1998, 129–133; Черкезова 1994, 111). As a result of the following interglacial period the so called Karangatian transgression appeared (40,000–30,000 BPE) and the connection with the Mediterranean was once again reestablished. Thus, the salinity of the water rose. The level of the basin increased above what it is today entering transgressively into the mouths of the rivers and shaping lagoon lowlands. It was named Karangatian Sea (Крыстев et al. 1990b, 215). The subsequent Post-Karangatian regression began with the last glacial period Würm and continued until the end of the Pleistocene (14,000/13,000 BPE). It greatly reduced the waters of the World Ocean and the sea level dropped successively to minus 90m to 100m and according to some other scholars even to minus 120m below the contemporary level (Димитров et al. 1979, 74; Михова 1998, 64; Балтаков 2003, 80 and bibliography). The maximum regression coincides with the climate minimum and is dating from 18,000 BPE. This circumstance led to a disconnection between the Black Sea basin and the Mediterranean. The withdrawal of water turned a large part of the shelf into an alluvial plain and caused intensive erosion processes whereat the rivers along the coast cut their beds and formed deep river valleys. Today sections of them cross the contemporary shelf. Due to the erosion at many shelf locations, the earlier Karangatian and Proto-Euxine accumulations have been taken away (Крыстев et al. 1990a, 346; Кръстев 1988, 36–43, fig. 1; Черкезова 1994, 112, fig. 2). As

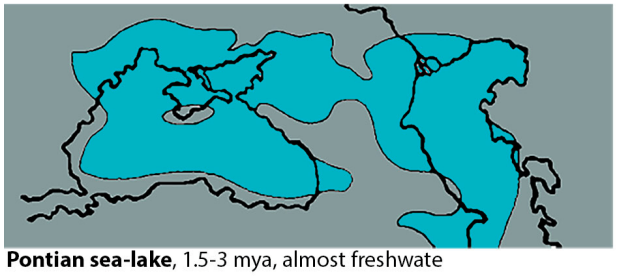
1 In the related literature these settlements are often termed pile dwellings or lake settlements. The authors of the current article prefer to use the term submerged settlements as most accurate and neutral and better reflecting the archaeological context of these sites that were built and existed on land (or on shore line) and only consequently were inundated and submerged due to major environment changes.



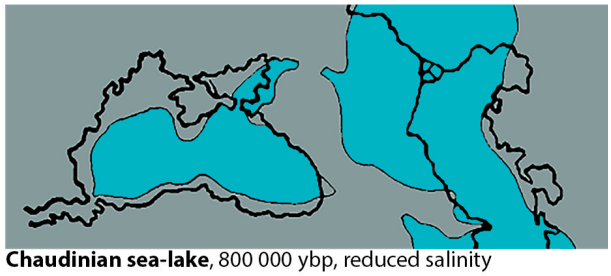
Sarmatic sea, 5-7 mya, brackish bassin



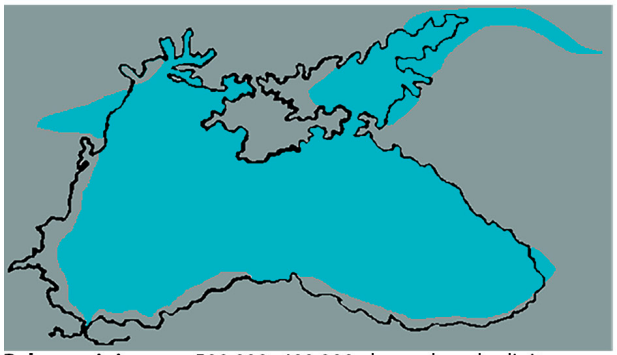
Meotic sea, 3-5 mya, connection with the ocean, high salinity



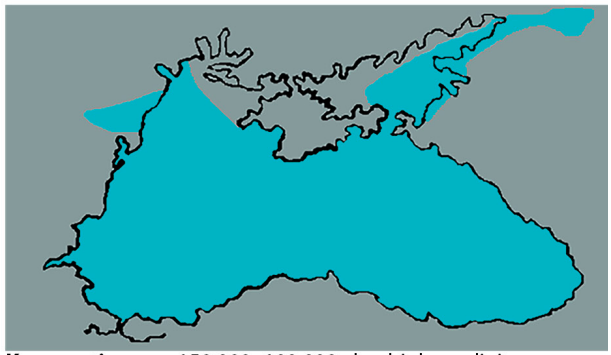
Pontian sea-lake, 1.5-3 mya, almost freshwate



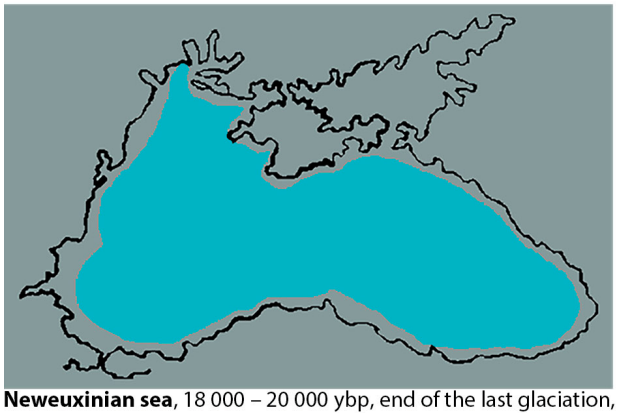
Chaudinian sea-lake, 800 000 ybp, reduced salinity



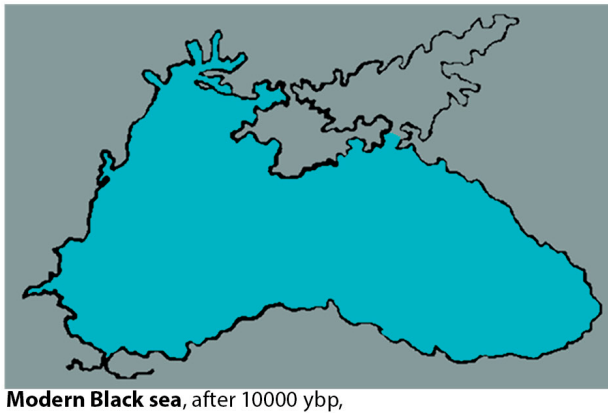
Paleoeuxinian sea, 500 000 -400 000 ybp, reduced salinity



Karagantina sea, 150 000 -100 000 ybp, higher salinity



Neweuxinian sea, 18 000 – 20 000 ybp, end of the last glaciation,



Modern Black sea, after 10000 ybp,

Fig. 1. Maps of the described Black Sea basins.

a result of this regression the New-Euxine Lake/Sea was formed as a slightly salty basin. Its coastal area was marked by accumulative shore shafts at a depth of 80m to 90m along the periphery zone of the shelf. At the end of the Pleistocene and the beginning of the Holocene the post-glacial transgression began. According to radiocarbon dating, its beginning has been related to ca. 14710 ± 1100 BPE (Михова 1998, 64 f.). The transgression developed with regressive and transgressive phases during periods of warming and cooling of the climate. The initial phase is known as New-Euxine transgression running at the very end of the Pleistocene. The good preservation of the flooded shafts indicates rapid rises in sea level caused by the melting ice and the flow of rivers as well as by the

established connection with the Caspian Sea which out flowed into the New-Euxine Sea. With a gradual rise in sea level the basin reached ca. -20m to -30m and according to some other opinions to -30m to -34m compared to the contemporary one. The second transgressive phase, running through the Holocene, was associated with the second half and the maximum of the global Flandrian transgression. During this stage the Mediterranean level rose above that of the Black Sea and triggered the influx of Mediterranean waters into the Black Sea. The academics are dating the establishment of the connection differently: from the late 10,000 BPE to the late 4,000 BPE (Yanko-Hombach et al. 2011, 146–162 with bibliography). Initially a slightly salty basin was formed with a limited Mediterranean fauna, fed by a multitude of inflowing rivers. Subsequently, at the maximum of the Flandrian transgression, the flow of the Mediterranean water led to formation of the salty New-Black Sea basin (Крыстев et al. 1990a, 346). This change of the chemical composition of the Black Sea water had catastrophic consequences for the Black Sea flora and fauna. The mass extinction of organisms was associated with the accumulation of a sapropel layer among the deep sediments and the accumulation of hydrogen sulphide gas in deep sea waters. The formation of the contemporary lagoons along the Black Sea shores began during this transgressive phase.

The evolution of the Black Sea basin and its region is a quite disputable and controversial topic and any of the hypotheses for the stages of basin transformations can be supported or challenged with a number of arguments. Nevertheless, in the course of the intensive phases of the New-Black Sea transgression alternating with stages of regression, the coastal settlements from the Late Chalcolithic Age (LCA) and Early Bronze Age (EBA) along the Bulgarian Black Sea coast were flooded and today we find them up to -10m.

Although it is only 376km long, the Bulgarian Black Sea shore displays well expressed regional peculiarities with pronounced tectonic instability and heterogeneity. Three main parts are clearly outlined different in geological structure as well as in dynamic behaviour (Попов/Мишев 1974, 22, 31–34, 47 f.; Пейчев/Димитров 2012, 106–145; see Dimitrov, this volume, chapter 1).

(1) The region between Rezovska River and Prosenishki Fault or most commonly Cape Emine. The region can be extended further south to Iğneada and the area between the cities of Samsun and Bafra in the Republic of Turkey as well as around the estuary of the Rioni river in Georgia. The seashore between the Rezovska river and Cape Emine has been split by a series of deep faults (reaching the surface), depressions and river valleys. In active tectonic processes this plate exhibits a constant tendency to sink. The southern sector of the Bulgarian Black Sea coast consists of sandy bays, lagoons and lakes interrupted by rocky ridges such as Medni Rid which are gradually rising to about 200m to 400m above sea level, up to 10km away from the seashore. The winds, wave activity, abrasion and alluvial processes are the main elements shaping the relief to form beaches, dunes, river estuaries, *limans*, lagoons and river valleys along the coast. The winds in the coastal zones are often more severe than in the rest of the hinterland. The northern and eastern ones dominate. The winds blowing from southeast are rarer, though equally strong (Попов/Мишев 1974, 110–113, 127 f.; Велев 2002, 155 f.). Vast areas in this region were flooded even with a minimum rise in sea level periodically passing from shoreline to sea shelf and back to mainland during periods of regression and transgression.

(2) The region between Cape Emine and Cape Shabla. Here the Moesian Plate which is the base of the high seashore north of Cape Emine is monolithic; the coast is high without any faults reaching the surface. For that reason any strongly expressed vertical tectonic fluctuations are missing there to compensate for the rise and fall of the sea level through their movement. Furthermore, there are only two larger, deep-cut river valleys, those of the Kamchia and Devnenska rivers. Today the latter represents a *liman* lake (the system of Varna and Beloslav lakes) as all the submerged settlements found so far in the region are concentrated around their shores. There the settlements are under water between 4m and 8.5m for the valley of Devnenska River is characterised by negative tectonic movements combined with a rise of the sea level (Попов/Мишев 1974, 50). The settlements in the rest of the region are located on high coastal plateaus.

(3) The region north of Cape Shabla to Durankulak and the Romanian/Bulgarian border. The region can be extended further north to the Danube River delta. There the continental plate is stable but the seashore is low and sloping composed of Sarmatian limestone covered with a thick layer of loess. The settlements there are located mainly on the mainland as the periphery of those from the ECA and the EBA are about 0.50m to 1m deep below the contemporary sea level (Durankulak in Bulgaria and La Ostrov in Romania). Additional data on the rise of the sea level in this region during and after prehistory come from single burials from the Copper Age now inside the sea about 2m deep. They mark a lower sea level compared to the contemporary one as initially the graves were located on the mainland dug into the loess layer.

History of Research

The first submerged prehistoric settlements became known in the mid-19th cent. AD and were found in a series of Alpine lakes in Switzerland, and afterwards in France, Italy, Austria, Germany and Slovenia. The first archaeological excavations of such a site were carried out in 1853 near the small town of Meilen-Rorenhaab along Lake Zurich directed by Ferdinand Keller. He created the theory that they were lake settlements constructed on platforms above the lake water similar to the Paeonian settlement from the 5th cent. BC in the Prasias Lake mentioned by Herodotus (Πρασιάς, today Kerkini, Doyran Lake) (Herodotus, Histories, Vol. V, Chapter 16). Basically, Keller's theory concerning settlements located in inner water basins (lakes, river estuaries and swampy places) is still valid today (Keller 1866). Similar discoveries were made in the early 20th cent. in the Ohrid and Prespa lakes in what is today the Republic of North Macedonia. All of them were located in inner fresh water basins without any direct connection to the sea. By the example of Keller, these sites were interpreted correctly as lake settlements.

In 1921, when digging a channel connecting Varna and Beloslav lakes, the first prehistoric settlement located below the sea level in Bulgaria was revealed (Шкорпил/Шкорпил 1921, 79 f.; Попов 1929, 10). Later during some construction and dredging works, similar sites or materials were found in the Varna lakes, Atanasovsko lake (Burgas), Sladkite Kladentsi and the fishing port south of Burgas, Atia navy port, Sozopol harbour, the bay at the mouth of the river Ropotamo, the Stomopolu Lagoon near Primorsko, the south bay of Kiten (Urdoviza) and the area of Ahtopol.

In the course of the 1960s, 1970s and 1990s some of these sites were explored more carefully. First the archaeologists Ara Margos, Goranka Toncheva and Ivan Ivanov made observations on submerged sites during different industrial constructions in the lakes of Varna. This was a serious step ahead in the study of archaeological structures of the settlements in question providing new data and observations, many of them still valid today. Ivan Ivanov was the first to present the assumption that the settlements in the Varna lakes were located on the mainland during their existence (Иванов 1980, 37; 1981, 289–291). The data collected in the course of more than 60 years of interdisciplinary marine studies quite logically raised doubts about the possibility of having lake settlements in sea bays. Nowadays it is accepted that these settlements had been constructed on the ancient mainland.

The research of Ivan Galabov, Velizar Velkov, Lyuba Ognenova, Ara Margos, Goranna Toncheva Michael Lazarov, Bozhidar Dimitrov, Ivan Karayotov, Kalin Porozhanov, Atanas Orachev, Ventsislav Popov and Hristina Angelova resulted in the localisation, study and interpretation of submerged archaeological sites from different periods found within marine environment.

At the very end of 1980s and the early 1990s, applying archaeological and interdisciplinary methods, the Centre for Underwater Archaeology in Sozopol continued the research of the known sites in the Urdoviza Bay near Kiten and in the harbour of Sozopol (Ivanov 1993, 21 f.; Porozhanov 1991, 111; Draganov 1995, 228; 1998, 214–218; Porozhanov 1998, 17; Angelova/Draganov 2003, 12–14; Драганов 1990, 172; Порожанов 2004, 312 f.). Despite the rescue nature of these studies, they contributed greatly with larger explored area, involvement of archaeologists working underwater,

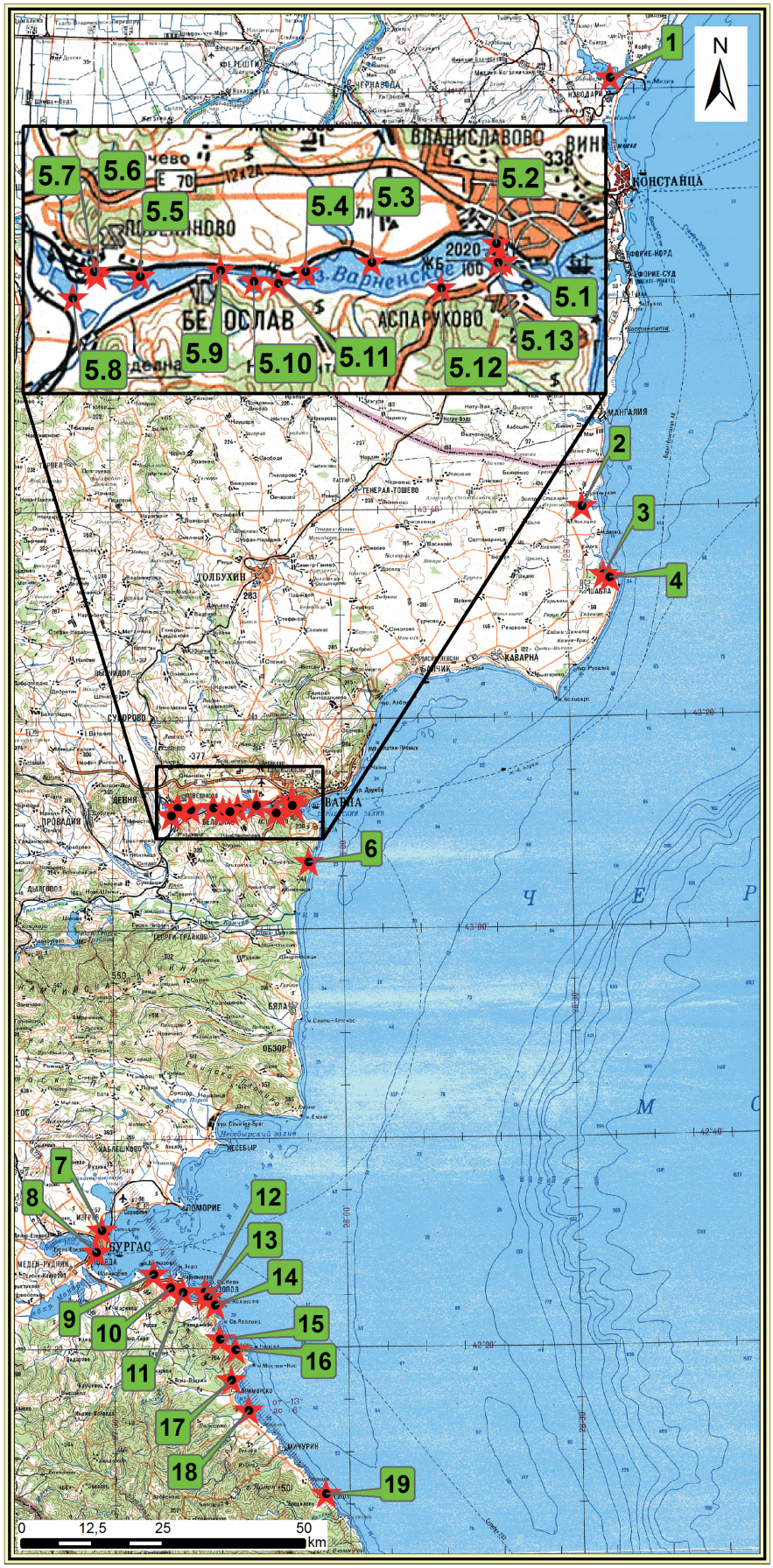


Fig. 2. Map of the submerged and seashore prehistoric settlements along the Western Black Sea coast. 1 La Ostrov, Romania, 2 Durankulak, 3 Shabla, 4 Shabla Tuzla, 5 Varna Lake end Beloslav lake sites, 6 Pasha Dere, 7 Atanasovsko Lake, 8 Burgas Fishing Port and Sladkite Kladentsi, 9 Atia, 10 Garmitsa, 11 Akladi Cheiri, 12 Sozopol – the Harbour, 13 Sozopol – the fire station/ the stadium, 14 Budzhaka, 15 Alepu Beach, 16 Ropotamo, 17 Stomopolu, 18 Kiten – Urdoviza, 19 Ahtopol.

	Site	Age/Culture/^{14}C	Type/Architecture	Location on the Terrain
1	La Ostrov, Romania	Late Neolithic (Hamangia I–IV phase, 5250 BP/ phase Varna – 4550 BC) Late Copper Age (Varna – 4100 BC)	Seashore settlements and necropolises	Tell in a lagoon
2	Durankulak – Golemiyat Ostrov – SW coast	EBA/ Cernavodă III; 3100–3000 BC Late Copper Age (Varna 4100 BC) Late Neolithic (Hamangia I–IV phase 5250 BP/ phase Varna 4550 BC)	Submerged settlement/seashore settlements and necropolises	EBA layer 1,5m below sea level in the lake Tell on a natural rocky hill in a lagoon Late Neolithic and Copper Age burials on the mainland below contemporary sea level
3	Shabla, Novite Lozya	Copper Age; Late Neolithic Hamangia II, III, IV	Seashore settlements	Open settlement on the mainland about 500m from the sea near Shabla Tuzla
4	Shabla Tuzla – at the southern end of the swamp, about 30m away from the shore (Peev 2008, 303 f.; 2009, 89 f.)	Copper Age – Culture Varna 4300–4100 BC 5400–5200 BP	Submerged necropolis – two graves	Two Copper Age burials in the sea about 2m deep
5	Varna Lakes (Varna lake end Beloslav lake)	EBA Cernavodă II – Ezarovo (2980–2800 BC) EBA Ezero AB (3180–2980 BC/ 4400–4280BP) Ezero B1 (4080–3900 BP) Copper Age Varna (4300–4100 BC/ 5400–5200 BP)	More than 15 submerged settlement sites	Up to -8.5m below sea level in a lagoon. They were located along both banks of Devnenska River mostly on mouths of small rivers and creek coming into the Devnenska river
6	Pasha Dere	Late Copper Age	Settlement, yet unexplored – single pottery fragments	Located on the northern Pasha Dere Cape. About 6–8m above contemporary sea level
7	Atanasovsko Lake	Neolithic, Copper Age, and EBA?	Seashore settlement/s ?	Prehistory artifacts, probably from several settlements found on the mainland during construction works close to the sea and ca. 2.5m in the groud, at a depth around the actual sea level; in area of Atanasovsko Lake and near St. Athanasius Church in Izgrev residential area, Burgas
8	Burgas – Fishing Port and Sladkite Kladentsi	Neolithic and EBA?	Probably settlements	Prehistoric artifacts from the sandbars between Vaya Lake and the sea in the region of Sladkite Kladentsi; artifacts from dredging works in Port Burgas between 6 and 12m deep
9	Atia	Late Copper Age, Early Bronze Age	Submerged settlements	Prehistoric artifacts from dredging works in the Atia Military Base Port 7–9m deep?
10	Garmitsa, Chernomorets village	Late Neolithic	Seashore settlement	About 1800m from the contemporary coast line and 50–60m above sea level
11	Akladi Cheiri, between Sozopol and Chernomorets	Late Neolithic, Early Copper Age	Seashore settlement	About 150m from the contemporary seashore

	Site	Age/Culture/^{14}C	Type/Architecture	Location on the Terrain
12	Sozopol – the Harbour	EBA (Cernavodă III) 3100–3000 BC Finale Copper Age (4140–3850 BC)	Submerged settlements	Up to 7m below sea level, along open sea bay close to Patovska River
13	The fire station – the stadium, Sozopol	Late Neolithic	Seashore settlement	About 20m from the contemporary coast line and ca. 6m above sea level
14	Budzhaka, South of Sozopol, close to Kavatsite site	Late Neolithic	Seashore settlement	Between 20 and 30m above contemporary sea level
15	Alepu Beach, South of of Dyuni resort	Late Neolithic, Early Chalolitic?	Seashore settlement	Located under a sandy dune, at a beach, ca. 20m from the sea. Alepu Swamp begins 50m west
16	Ropotamo	EBA (Cernavodă II)/ Ezerovo-Ezero B1 (2980–2800/4080–3900 BP)	Submerged settlement	Up to 6m below sea level in the bay in front of the river estuary
17	Kachkata, Stomopolu, Primorsko	Late Neolithic	Seashore settlement?	About 600m from the sea. Artifacts found ca. 7m below sea level, in a seashore lagoon
18	Kiten – Urdoviza	EBA (Cernavodă II) Ezero AB (3180–2980 BC/ 4400–4280 BP 2900–2700 after Kuniholm or 2850–2600 BC	Submerged settlement	Up to 9m below sea level near sea bay along the ancient left bank of the river Karaagach
19	Ahtopol	Prehistoric pottery	Seashore settlements?	Single artifacts from the territory and the aquatory of Ahtopol

Table 1. Submerged and seashore Prehistoric settlements along the Western Black Sea coast.

stratigraphic observations and employment of interdisciplinary studies as basic instruments of underwater archaeology. Furthermore, during the same period the submerged archaeological sites in Bulgaria were dated successfully by dendrochronological and ^{14}C analyses.

Correlation has been established between the dates of the settlements, the depth they are found at against the contemporary sea level, and the bottom sediments in which they are found. The sites from the Neolithic known so far are not below the sea level (Klasnakov 2010, 1–27; Лещаков/Недев 2008, 49 f.; Лещаков et al. 2008, 51 f.; 2009, 74 f.; Лещаков/Класнаков 2009, 54 f.; 2010, 58 f.; Недев et al. 2008, 309 f.). They are significantly earlier than the submerged settlements and although today they are to be found in close proximity to the seashore, in the past they have hardly had a direct interaction with the sea. Hypotheses have been proposed that the settlements from the final Copper Age that appear at the depth between 7m and 9m below the contemporary sea level were located on the ground on terraces of lower costal rivers valleys or along fresh or brackish water *limans*. The ones from the EBA are found at similar or same places and depths but were buildings on pile platforms. An archaeological hiatus between the LCA and the EBA has been documented in the profiles of the settlements and also found in a series of sites on the mainland dating to the 4th mill. BC. This hiatus marks flooding and a natural sedimentary process in a water environment. It has been documented that the settlements were flooded within a short period of time as they were destroyed by natural processes (Draganov 1995, 225–242; 1998, 203–221).

Table 1 presents in synthesised form information about submerged settlements along the western Black Sea coast (*fig. 2*). It contains also the seashore settlements here cited only for comparison.

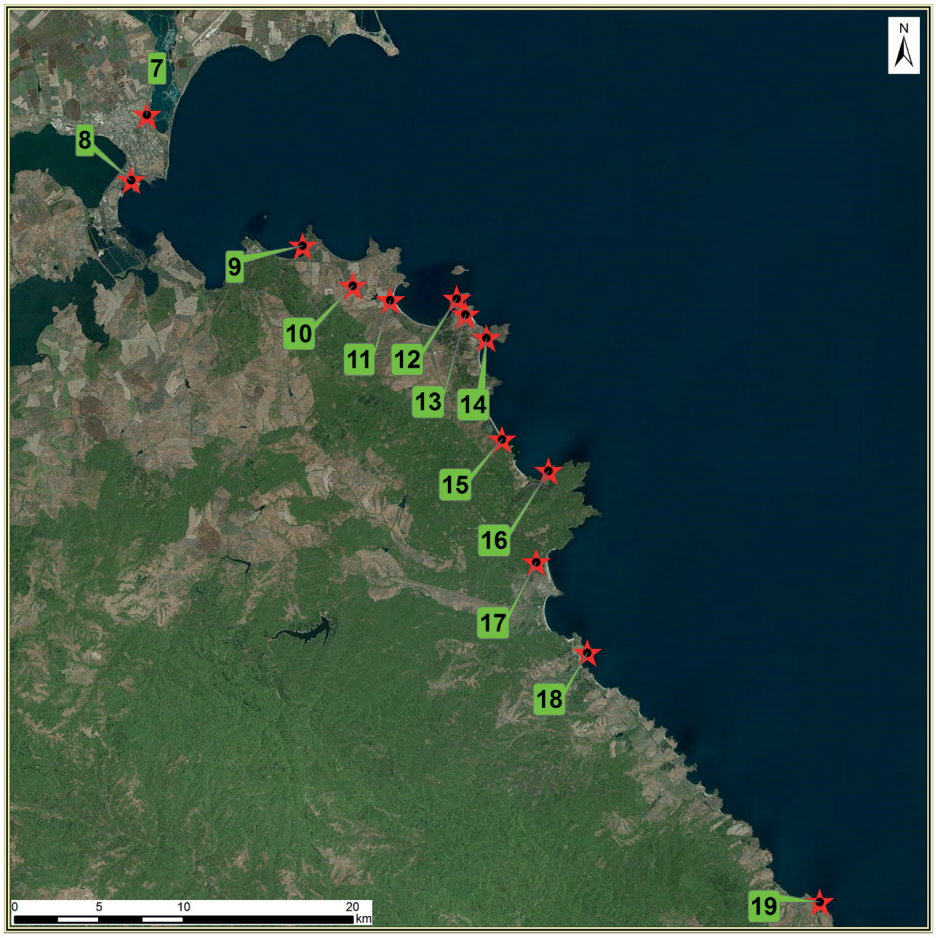


Fig. 3. The settlements South of Burgas, satellite image. 7 Atanasovsko Lake, 8 Burgas Fishing Port and Sladkite Kladentsi, 9 Atia, 10 Garmitsa, 11 Akladi Cheiri, 12 Sozopol – the Harbour, 13 Sozopol – the fire station/ the stadium, 14 Budzhaka, 15 Alepu Beach, 16 Ropotamo, 17 Stomopolu, 18 Kiten – Urdoviza, 19 Ahtopol.

There are informations of other sites along the seashore where prehistoric artefacts have been discovered in the course of various activities; however, because of the vague context and type of findings, they are not considered here.

Prehistoric Settlements Below Present Sea Level South of Burgas

Data on prehistoric settlements which lie today below sea level in the area of Burgas and south of it refer to occasional discoveries of archaeological material during various construction and excavation activities on building ports or other large-scale hydro-technical works (*fig. 3*). Some limited regular and rescue archaeological excavations have been carried out only in the harbour of Sozopol, in the bay in front of the Ropotamo river estuary and near Kiten (Urdoviza) as the explored area only of the latter one (about 900m^2) can be considered as significant. Thus, despite the devoted efforts of several generations of researchers, the data on the submerged prehistoric settlements along the southern Bulgarian seashore remain fragmented and many of the problems associated with them unsolved.

1. Atanasovsko Lake

The initial information about prehistoric artefacts from the region of Burgas that could be related to sites below the actual sea level is from 1925. Then, during digging channels for salt-extracting facilities in the south part of the Atanasovsko lake stone tools and pottery fragments were collected from a depth of 0.45m to 1.0m in the ground (*fig. 4.1–4.2*). A bit later similar artefacts were discovered nearby at a depth of ca. 2.5m in the ground (Миков 1925, 235 f.; Панделеев 1926/1927, 304–306; 1928/1929, 325–328). The prehistoric artefacts were dated to the Neolithic, Late Copper Age and Bronze Age and a view was put forward that they



Fig. 4.1. Probable location of the prehistoric finds from Atanasovsko Lake, topographic map 1:50,000.



Fig. 4.2. Probable location of the prehistoric finds from Atanasovsko Lake, satellite image.

belong to different sites (Gaul 1948, 175, Pl. 29; Draganov 1998, 212; Klasnakov 2010, 11; Миков 1933, 110; Лазаров 1975, 33, 133). The earlier publications are laconic and quite vague but the nature of the artefacts – pottery fragments, flint tools, stone axes, pieces of clay daub, stone hammers, stone battle balls, antlers and bovine horns, animal bones, a small model of a house, clay spindle whorls, stone weights (a round stone with a hole) and ceramic human figurines – suggests that probably they come from more than one settlement (*fig. 5: 1–4*). We have to note that these settlements were located inland near the shore, at an altitude close the present day sea level (up to 2.5m in the ground) and appear to contain Late Neolithic material as well.

2. Port Burgas

In 1968, during digging works connected with the construction of the 'Fishing Port' in Burgas, a couple of ceramic vessels were found (*fig. 6.1–6.2*). M. Lazarov dated them to the EBA (Лазаров 1975, 33; Lazarov 1974, 109). The localisation of the artefacts is only in general: 'Burgas, from the bottom of the sea, close to the antique settlement at 'Sladkite Kladentsi' (Лазаров 1971, 9). M. Klasnakov mentions that during dredging in Burgas port in 1968

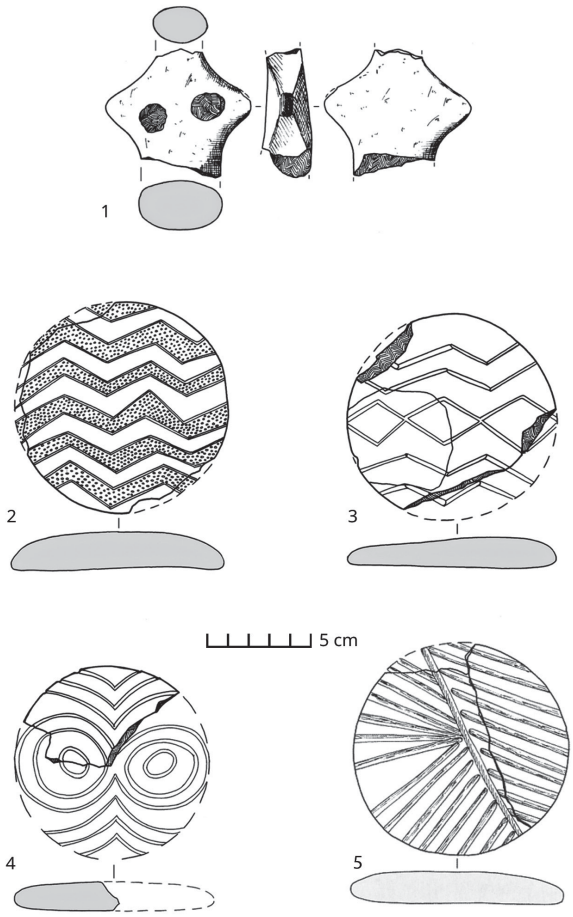


Fig. 5. Prehistoric finds from the area of Burgas: 1–4 Atanasovsko lake; 5 from the southern part of the bay, depth between 6 and 12m (after Klasnakov 2010; 2011).



Fig. 6.1. Probable location of the prehistoric finds from the area of Port Burgas, topographic map 1:50,000.



Fig. 6.2. Probable location of the prehistoric finds from the area of Port Burgas, satellite image.

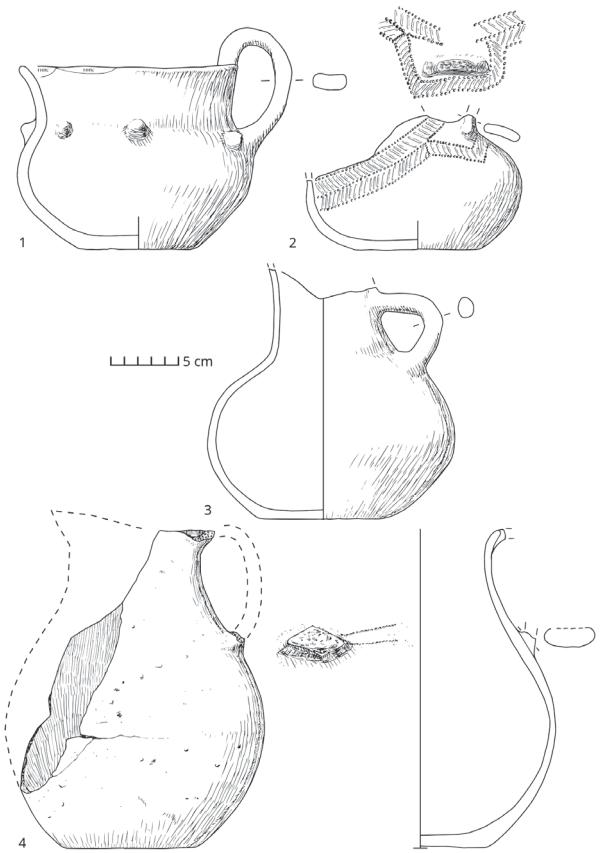


Fig. 7. Early Bronze Age ceramics from the area of Port Burgas. Courtesy of the Regional Historical Museum Burgas (drawings by H. Vasileva).

many archaeological artefacts were found (*fig. 7*). They were discovered in the southern part of the bay at a depth of 6m to 12m and about 500m from the shore. A disk-shaped lid relating to the Late Neolithic was also among the artefacts of this dredging (*fig. 5: 5*) (Klasnakov 2010, 11).

The area of their discovery is important from an archaeological and geo-morphological point of view. The large sandbar of Kumluka (in Turkish 'sandy') is located there dividing the Burgas Lake (Vaya) from the sea and the site of Sladkite Kladentsi. The name of the latter ('freshwater wells') comes from the high-debit freshwater springs which used to be an important source of drinking water for Burgas until the beginning of 20th cent. AD. The natural runoff of Vaya lake towards the sea is close to the springs. During antiquity a settlement (blooming in the 5th and 4th cent. BC) existed here probably as a trading centre (*emporium*) of Apollonia Pontica (Гълъбов 1950, 249; Гюзелев 2009, 98 f.). The settlement has not yet been revealed and only its necropolis partially explored as a sector of it is on the mainland below the level of Burgas lake (Лазаров 1975, 133). It is worth noting that among the artefacts from the antique necropolis at Sladkite Kladentsi single fragments from EBA pottery were also found (Гълъбов 1950, 249).



Fig. 8.1. Location of the prehistoric finds from the area of the Atia navy harbour, topographic map 1:50,000.



Fig. 8.2. Location of the prehistoric finds from the area of the Atia navy harbour, combined orthophoto image from 1918 and 2016. The image from 1918 shows the area before the construction of the navy facilities.

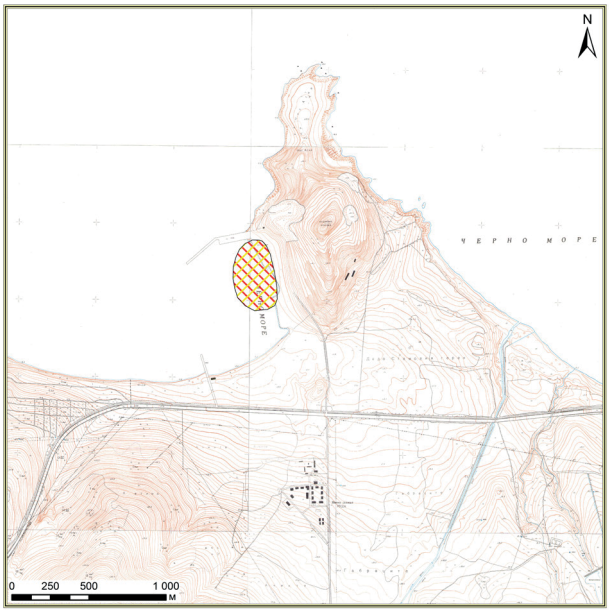


Fig. 8.3. Location of the prehistoric finds from the area of the Atia navy harbour, topographic map 1:5,000.



Fig. 8.4. Location of the prehistoric finds from the area of the Atia navy harbour, combined orthophoto image from 1918 and 2016.

3. Atia

The settlement was discovered in 1968 in the western bay of Atia Cape during the construction of the Atia Naval Base (*fig. 8.1–8.4*). There, below the sea bottom surface layer containing artefacts from antiquity and the Middle Ages, they found traces of prehistoric settlements. The pottery – whole shapes and fragments – is dated to the LCA and the EBA (Lazarov 1974, 109; 1993, 8 f.; Карайотов 1984, 186; Лазаров 1975, 33, 132; 2009, 10). The prehistoric materials were taken out from a depth of 7m to 9m (Лазаров 2009, 18). Lazarov reminds that the place where the settlement is located today is not well protected from the northern and eastern winds and explains this fact with the significant

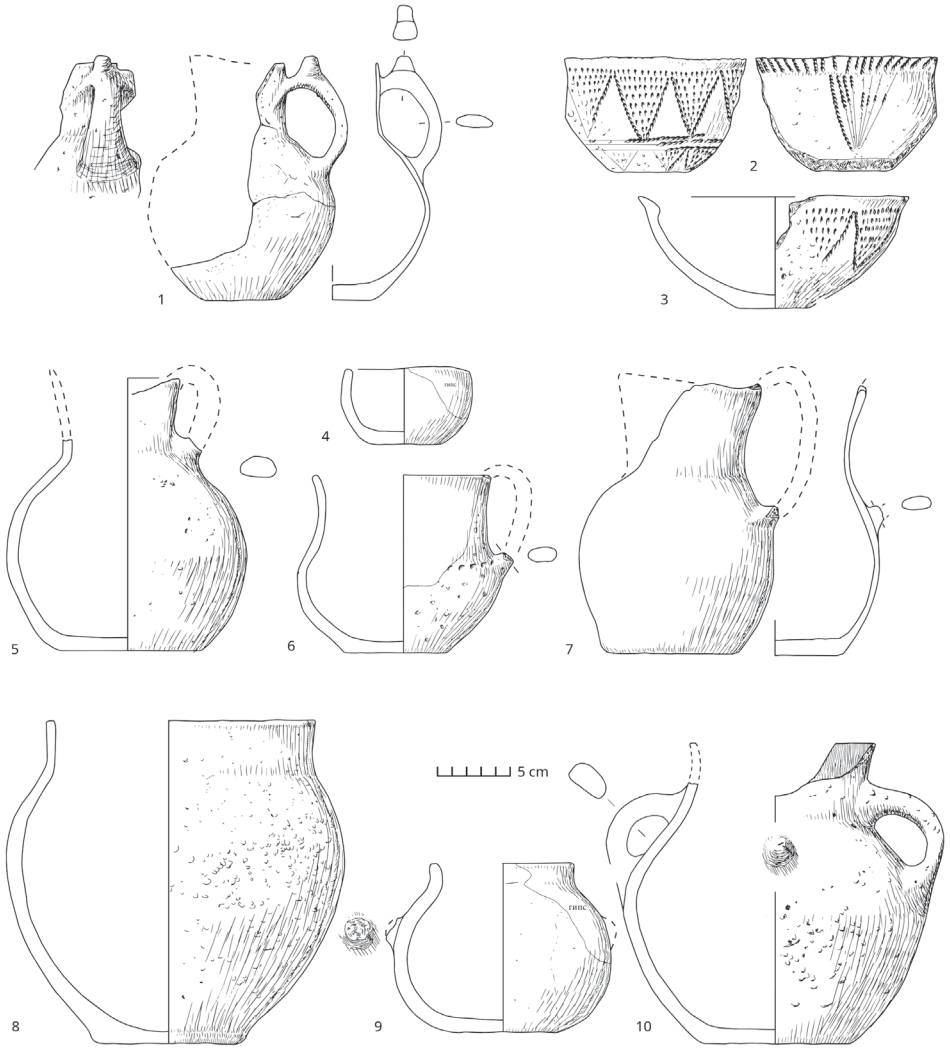


Fig. 9. Early Bronze Age ceramics from Atia gulf, discovered in 1968 during the construction of the navy port. Courtesy of the Regional Historical Museum Burgas (drawings by H. Vasileva).

change of the landscape in the region from prehistory to the present day (Лазаров 1993, 8). It seems that this site presents materials from the latest stage of the Late Chalcolithic on the western Black Sea coast and from the third phase of the EBA (*fig. 9*).

4. Sozopol

In 1927, during construction of piers and dredging works at the 'Old Harbour' of Sozopol about 300 pottery fragments from various dates, antique tomb stones and votive reliefs were taken out. Although there was not an archaeologist at the spot, information was collected that the pieces were found '… during dredging the sea bottom at a depth of 3m to 3.5m or in total 5m to 6m (Панделеев 1928/1929, 328).

Initially the interest of the researchers was mainly focused on the antique painted black-figure pottery and the local grey one from the Late Iron Age (Панделеев 1928/1929, 328; Гълъбов 1952, 93–118; 1965, 11). In the newer publications, these 1927 materials are referred to a submerged sector of an antique necropolis of Apollonia Pontica dating from the early 4th cent. BC (Panayotova 1994, 125–127).

The prehistoric pottery from Sozopol has been recognised by I. Galabov who mentions it vaguely a couple of times (Гълъбов 1950, 249; 1965, 11). M. Lazarov releases the information that a submerged settlement from the EBA was discovered in the harbour of Sozopol presenting photos and drawings of some vessels (*fig. 11*) (Горов et al. 1967, fig. 8; Lazarov 1974, 107 f.; Лазаров 1975, 9, 32–34; Klasnakov/Stefanova 2009, 1–9).



Fig. 10.1. Location of the prehistoric sites in the harbour of Sozopol, topographic map 1:50,000.

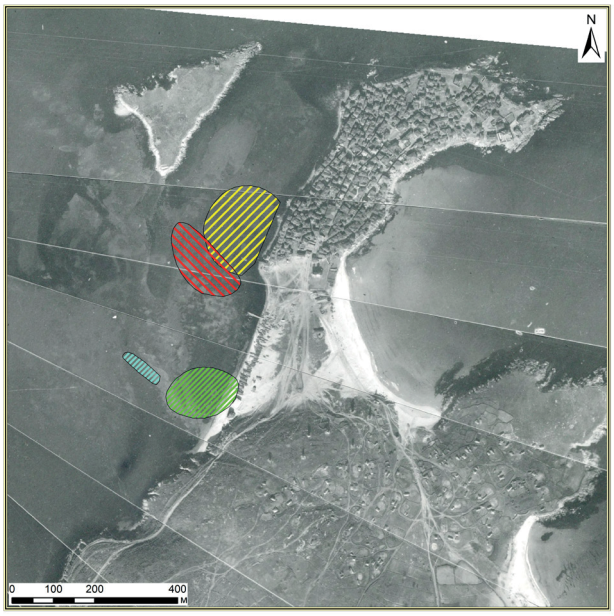


Fig. 10.2. Location of the researched part of the prehistoric sites in the harbour of Sozopol, orthophoto image from 1918: yellow – Late Chalcolithic settlement, red – Early Bronze Age settlement, blue – Late Bronze Age finds, green – Early Iron Age finds. The image from 1918 shows the area before the construction of the harbour facilities.



Fig. 10.3. Location of the researched part of the prehistoric sites in the harbour of Sozopol, topographic map 1:5,000: yellow – Late Chalcolithic settlement, red – Early Bronze Age settlement, blue – Late Bronze Age finds, green – Early Iron Age finds.

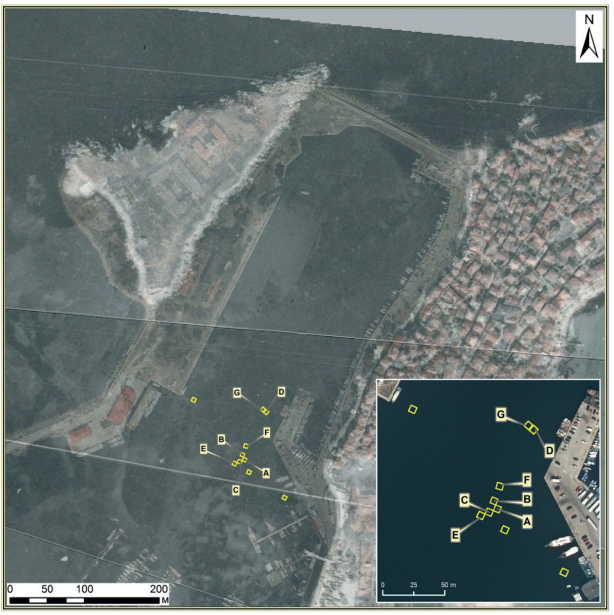


Fig. 10.4. Location of the archaeological trenches in the harbour of Sozopol, combined orthophoto image from 1918 and 2016. Note the great changes in the landscape in connection with the construction of the harbour facilities.

The first underwater archaeological research of the prehistoric settlements in the aquatory of Sozopol was carried out in 1986 and 1987. The reason for these excavations came with the dredging works in the harbour and the construction of the 'New Fishing Port' (Попов/Катинчаров 1988, 39; Порожанов 2004, 309–322). During the research for the first time it has been found out that a layer from the Late Copper Age is also present in Sozopol.

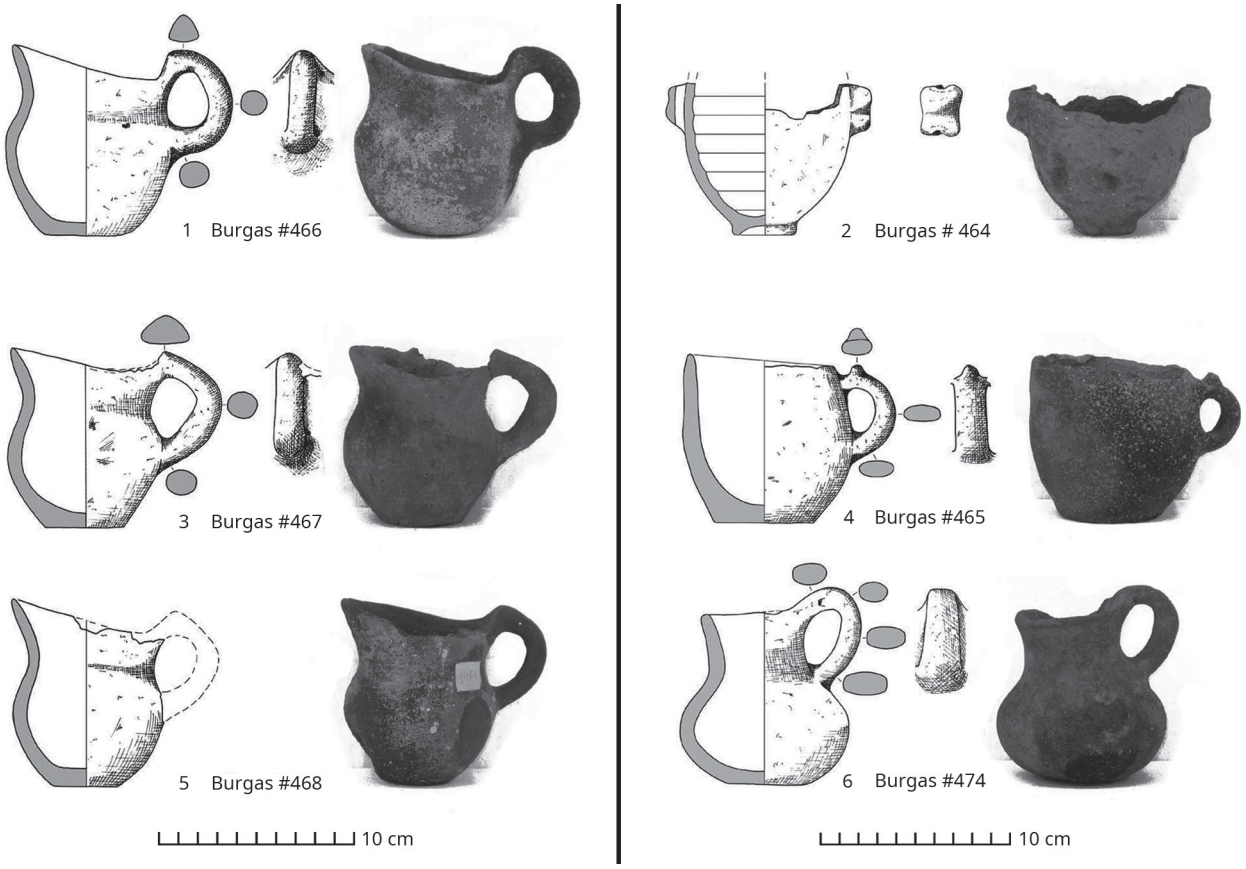


Fig. 11. Bronze Age pottery found during the dredging of the harbour of Sozopol in 1927 (after Klasnakov/Stefanova 2009).

In 1990 and 1993 two campaigns of regular underwater excavations were conducted aiming to ascertain the stratigraphy of the settlements, their dates and cultural affiliation, and also to clarify their localisation in the ancient landscape. The research was concentrated on three sectors conditionally called in some publications as Sozopol 1 (quadrants H, D and G), Sozopol 2 (quadrants A, B, C and E) and Sozopol 3 (*fig. 10.4*). Sectors 1 and 2 are about 60m apart in north/northeast direction (Angelova et al. 1995, 54 f.; Angelova/Draganov 2003, 20–22; Draganov 1998, 204). Due to the fact that the stratigraphic observations on the submerged settlements along the western Black Sea coast are extremely scarce, we shall present the results from Sozopol in greater details as for now they are the main pillar by which the other settlements can be better understood (*fig. 10.1–10.3*).

Sector Sozopol 1

In the zone of sector Sozopol 1 the sea bottom is at a depth of 4.3m to 4.6m. The uppermost layer (layer 1) is 0.35m to 0.50m thick composed of marine sediments and scattered archaeological material of various dates. This layer is badly destroyed due to the multiple dredging works in the port. Judging from the artefacts found and dating after the end of the 2nd mill. BC, after this date the place was a sea bay serving as a harbour.

The next layer in depth (layer 2) is also badly disturbed by dredging works and is even missing at certain spots. In the preserved sectors, its upper surface is flat. This circumstance is interpreted as a result of the formation of the layer in calm water. The layer (as a matter of fact better registered in sector Sozopol 2) is characterised by the presence of organic materials and has been

probably accumulated in a calm water environment. Layer 2 represents the upper badly destroyed level of the next layer 3 containing debris of a Late Copper Age settlement (Draganov 1998, 215; Ангелова et al. 1994, 17 f.).

Layer 3 is a preserved anthropogenic archaeological layer with many artefacts in situ. It begins at a depth of ca. 1m to 1.15m from the sea bottom as its thickness is ca. 0.20m. This layer displays the greatest concentration of archaeological artefacts – pottery, floor daub, walking levels and wooden structures – and has the character of a settlement. It has been determined that the end of the settlement was marked by a fire as its traces are to be seen on some of the wooden constructions and pottery fragments (Ангелова/Драганов 1994, 18).

Layer 4 is the natural terrain on which the Copper Age settlement was located. It has been shaped near a marine environment as all the shells, the small size gravel and sand testify. They appear at the base of layer 3 and increase in depth. At a depth of 1.8m the structure and contents of layer 4 resemble the ones at the bottom of a sea basin (Draganov 1998, 214). The layer has not been exhausted; however, it has been traced that it contains archaeological materials down to a depth of 2.1m to 2.3m from the surface of the sea bottom. These materials appear in negative shapes filled during the life of the settlement. The thickness in total of the Late Copper Age accumulation (Layers 2, 3 and 4) reaches 2.1m at certain spots. The archaeological materials have been traced to a depth of ca. 6.5m to 7.0m from the sea level. A main peculiarity of sector Sozopol 1 is the almost complete lack of artefacts from the EBA.

The Copper Age pottery from Sozopol can be related to the end of the age and synchronised with the Krivodol IV period (Георгиева 2004, 214–238). Its closest parallels come from sites dated after the end of the classical Gumelniţa/Kodzhadermen/Karanovo VI culture as Telish Redutite, Yagodina cave, Haramiyska dupka cave, Galatin Chukata and Rebarkovo (Вайсов 1992, 45–49; Аврамова 1981, 79–81; 1992, 240–247; Todorova/Avramova 2016, 249–268; Вълчанова 1983; 1984; Георгиева 1992, 339–346; 1994, 9–26; Georgieva 1995, 87–92; Гергов 1987, 44–54; 1992a, 347–357; 1992b, 49). The closest parallel is the material from Atia. Characteristic of the Sozopol chalcolithic ceramics is that they belong entirely to the Copper Age tradition but display some new elements of decoration and shape of certain kinds of vessels. It is noteworthy that the pottery from Sozopol shows parallels with the one from Varna lakes and Golyamo Delchevo generally in shapes but differs significantly in techniques and decoration patterns.

The vessels from Sozopol are hand-made. The Copper Age pottery is produced of fine clay and we can notice a correlation between the size of the vessel, its function and the degree of purifying the clay. The composition of the clay is characterised by inorganic temper and less often organic ones. The colours of the vessels are dark: brown, grey and black. The cups and bowls are entirely black. Some pots are brown in colour. The core of the section of the ceramics is black. We can conclude that most of the vessels have been baked in reducing conditions. In certain cases they were baked afterwards in an oxidising atmosphere. The general temperature of baking is not very high. The surfaces are very well processed and depending on the size of the vessel finely burnished or rougher. Some of the bigger shapes (dishes, bowls and pots with two handles) are very carefully burnished and decorated.

The repertoire of shapes is well known from the Late Copper Age sites: dishes, bowls, cups, jugs, pots, jars, lids and miniature vessels. The cups are the most numerous. The thickened rim of the mouth and the S-like profile with a pseudo-shoulder are a common feature of the bowls, cups and pots.[2] The small vessels with a round bottom are more specific, some of them have handles decorated with incisions and buds. These vessels seem to be the clearest expression of the Post-Chalcolithic elements in the Sozopol ceramic complex (*fig. 12–24*).

2 Some observations on the peculiarities of the ceramics from Sozopol were made in an unpublished master thesis 'Typology of the Ceramic from the Final Late Chalcolithic from the Sunken Site in the Sozopol Harbour' (in Bulgarian) defended by Gergana Mladenova in 2005 at the Sofia University 'St. Kliment Ohridski'.

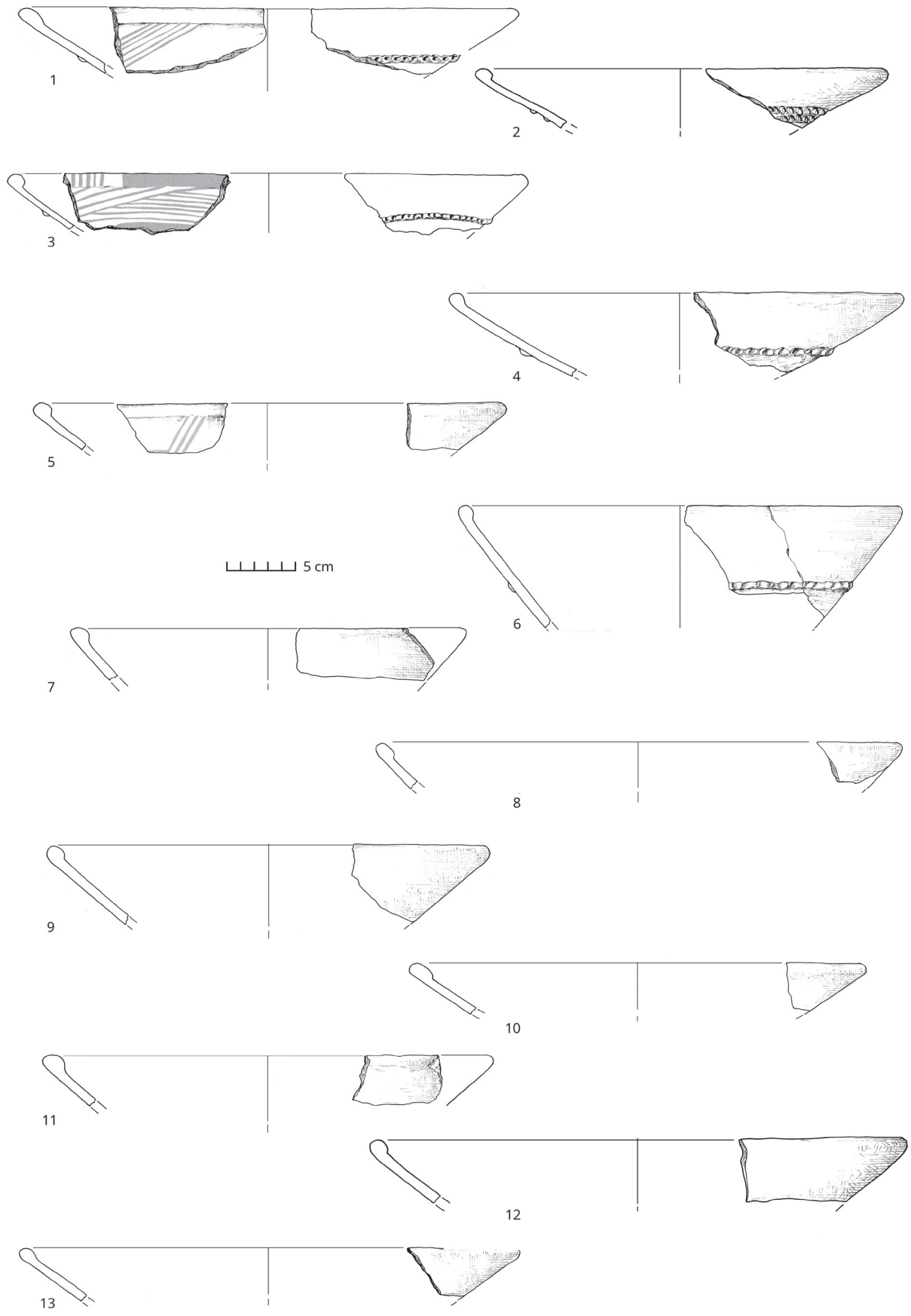


Fig. 12. Late Chalcolithic ceramics from the settlement in the harbour of Sozopol, excavation of the Centre of Underwater Archaeology in 1988, 1990, 1993 (drawings by N. Todorova, G. Mladenova, V. Petrova).

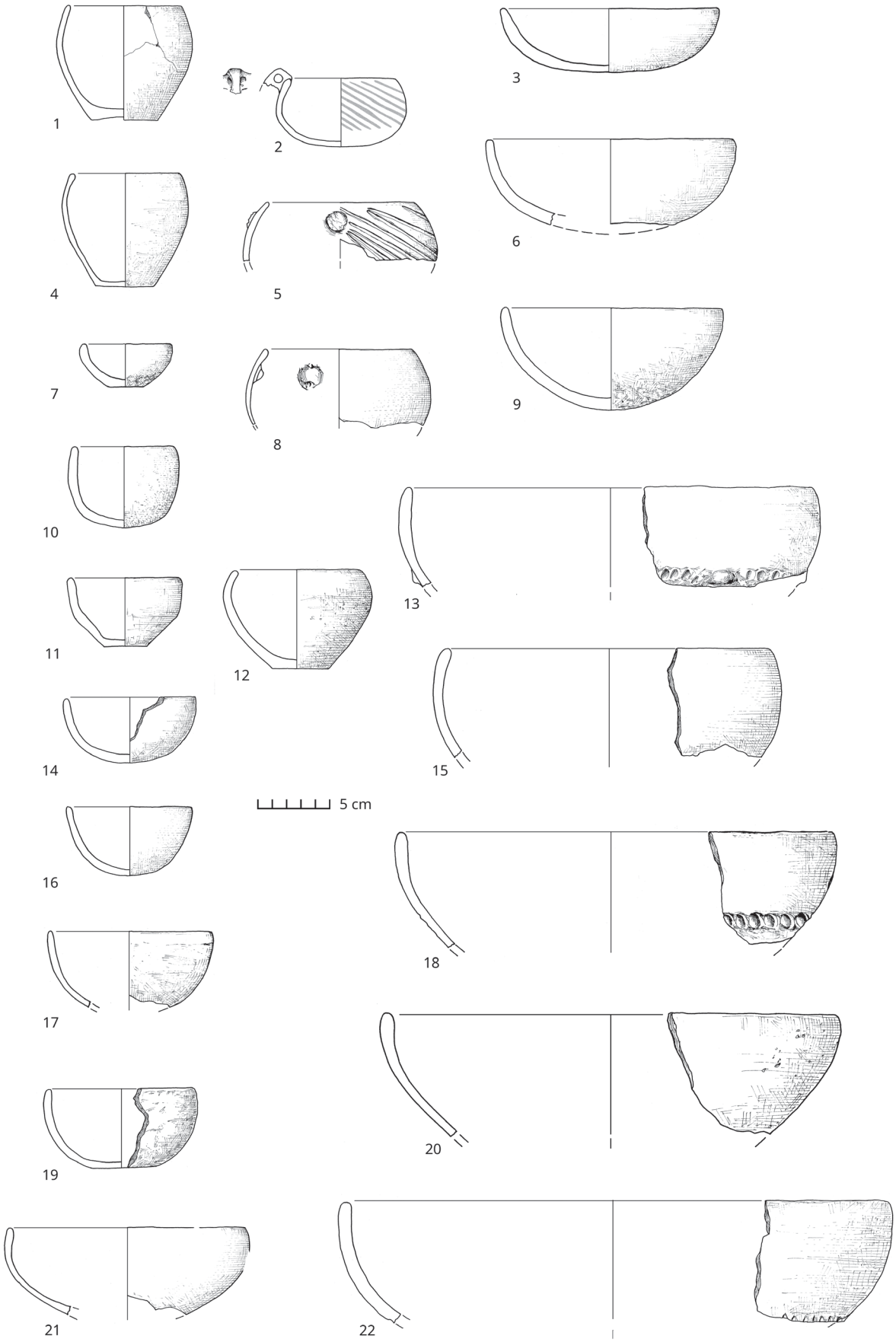


Fig. 13. Late Chalcolithic ceramics from the settlement in the harbour of Sozopol, excavation of the Centre of Underwater Archaeology in 1988, 1990, 1993 (drawings by N. Todorova, G. Mladenova, V. Petrova).

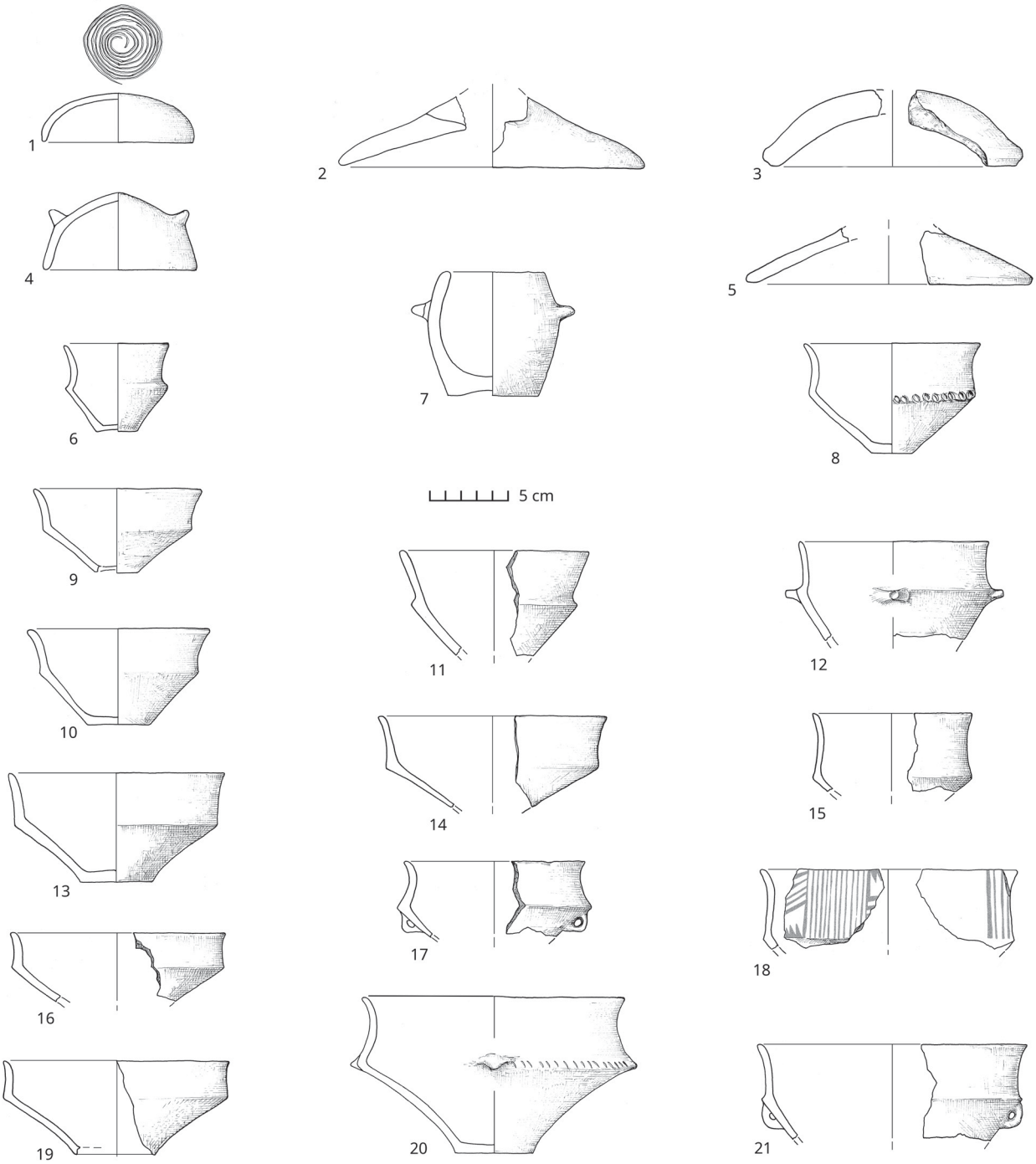


Fig. 14. Late Chalcolithic ceramics from the settlement in the harbour of Sozopol, excavation of the Centre of Underwater Archaeology in 1988, 1990, 1993 (drawings by N. Todorova, G. Mladenova, V. Petrova).

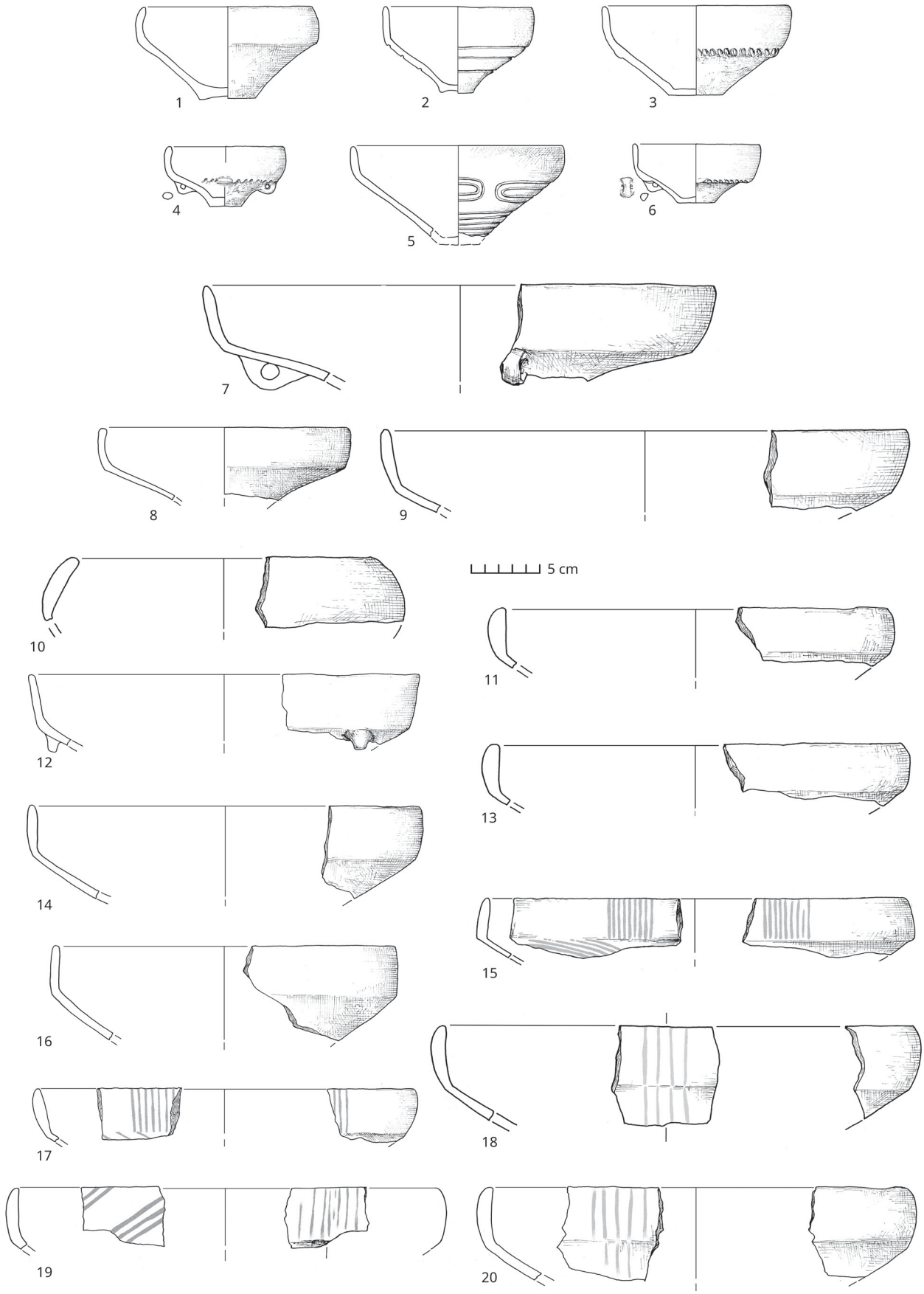


Fig. 15. Late Chalcolithic ceramics from the settlement in the harbour of Sozopol, excavation of the Centre of Underwater Archaeology in 1988, 1990, 1993 (drawings by N. Todorova, G. Mladenova, V. Petrova).

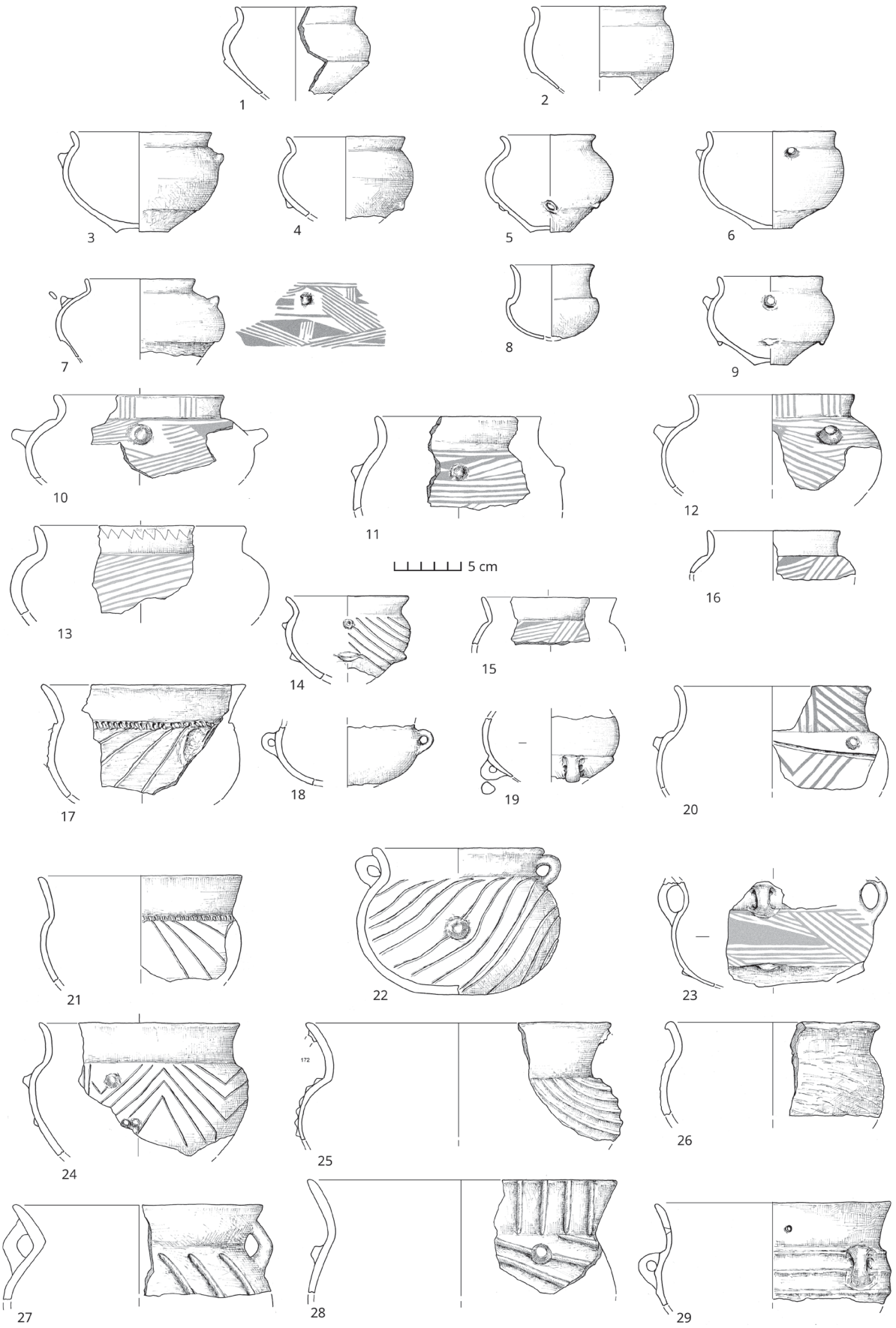


Fig. 16. Late Chalcolithic ceramics from the settlement in the harbour of Sozopol, excavation of the Centre of Underwater Archaeology in 1988, 1990, 1993 (drawings by N. Todorova, G. Mladenova, V. Petrova).

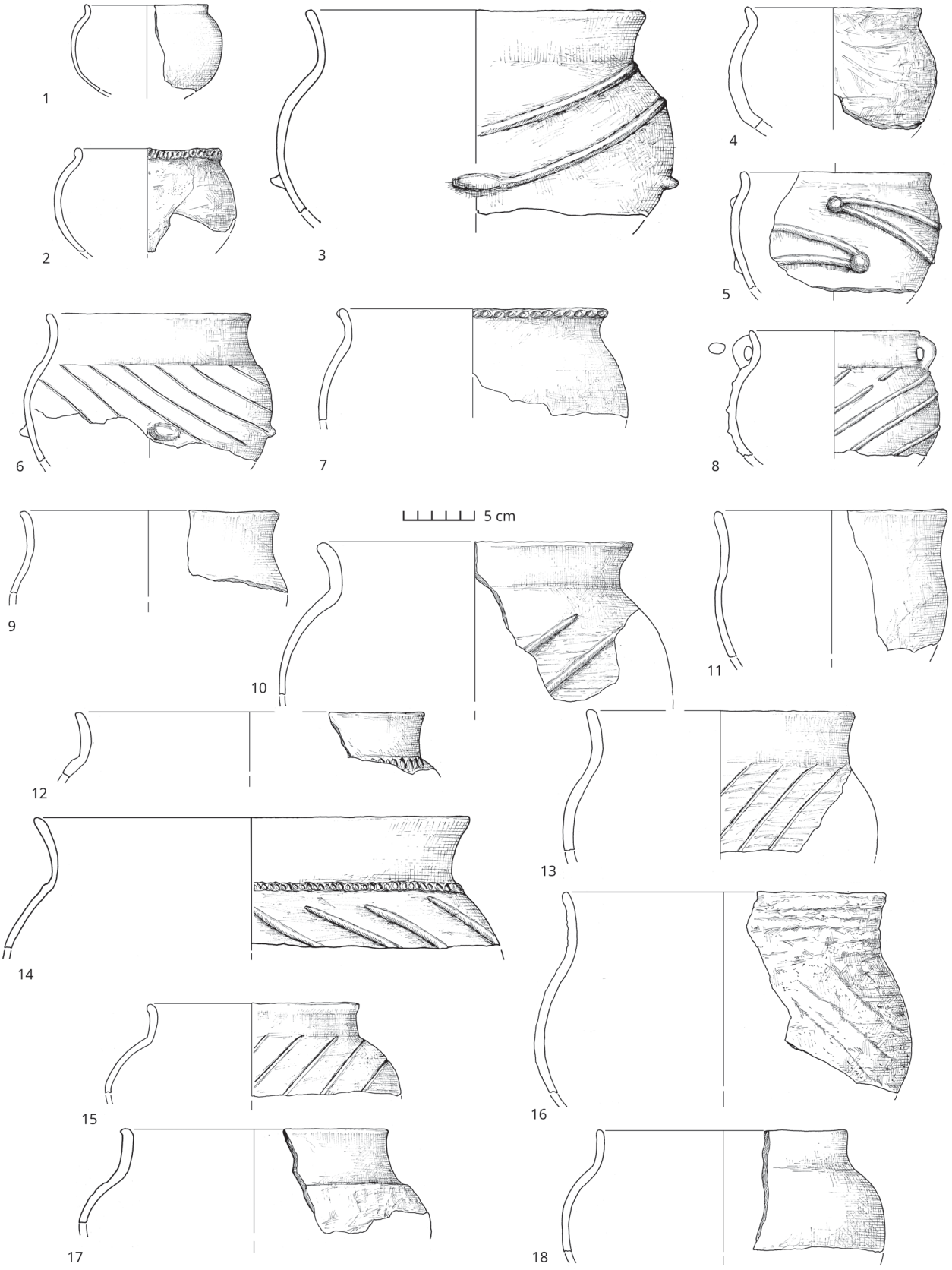


Fig. 17. Late Chalcolithic ceramics from the settlement in the harbour of Sozopol, excavation of the Centre of Underwater Archaeology in 1988, 1990, 1993 (drawings by N. Todorova, G. Mladenova, V. Petrova).

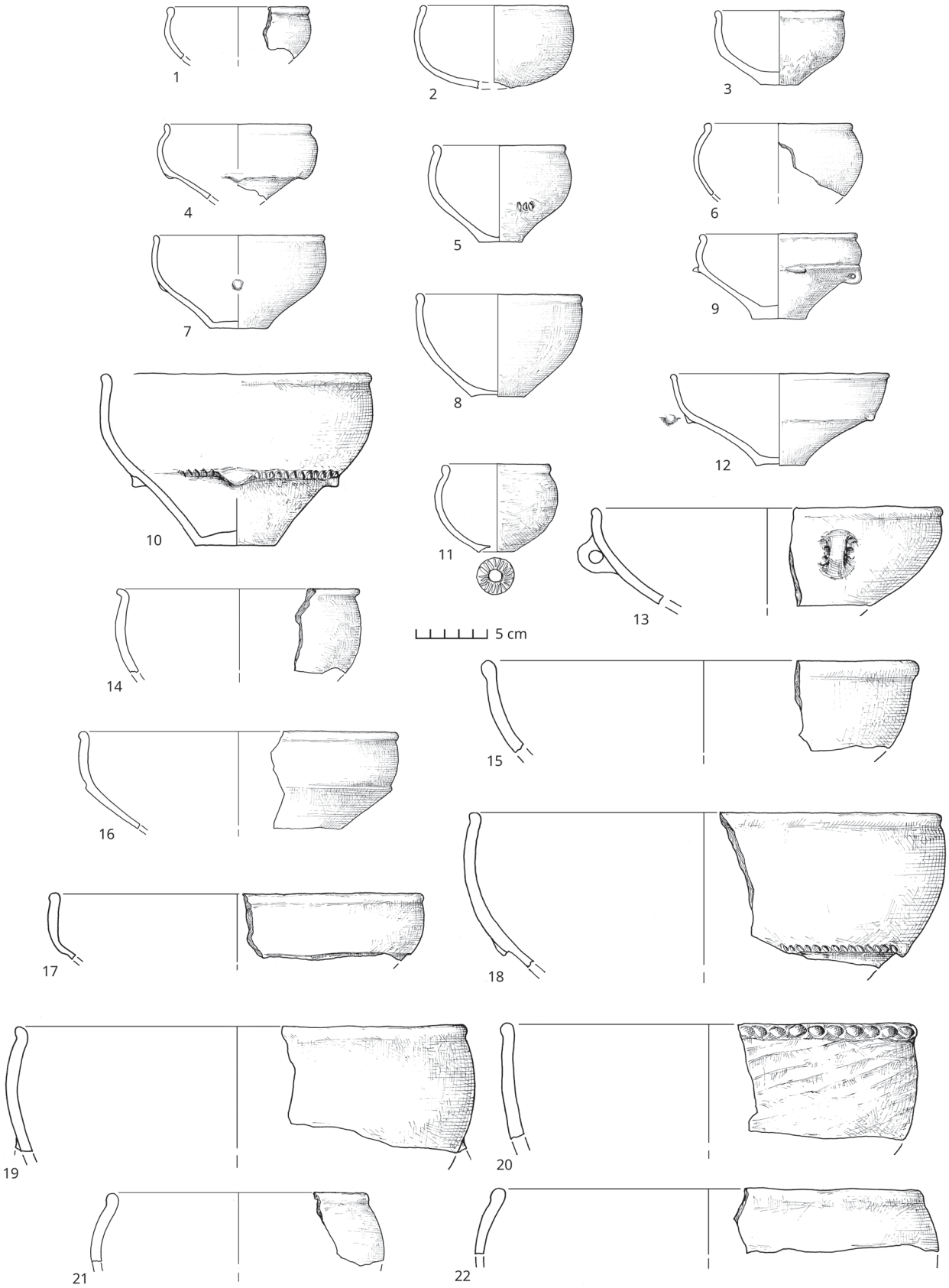


Fig. 18. Late Chalcolithic ceramics from the settlement in the harbour of Sozopol, excavation of the Centre of Underwater Archaeology in 1988, 1990, 1993 (drawings by N. Todorova, G. Mladenova, V. Petrova).

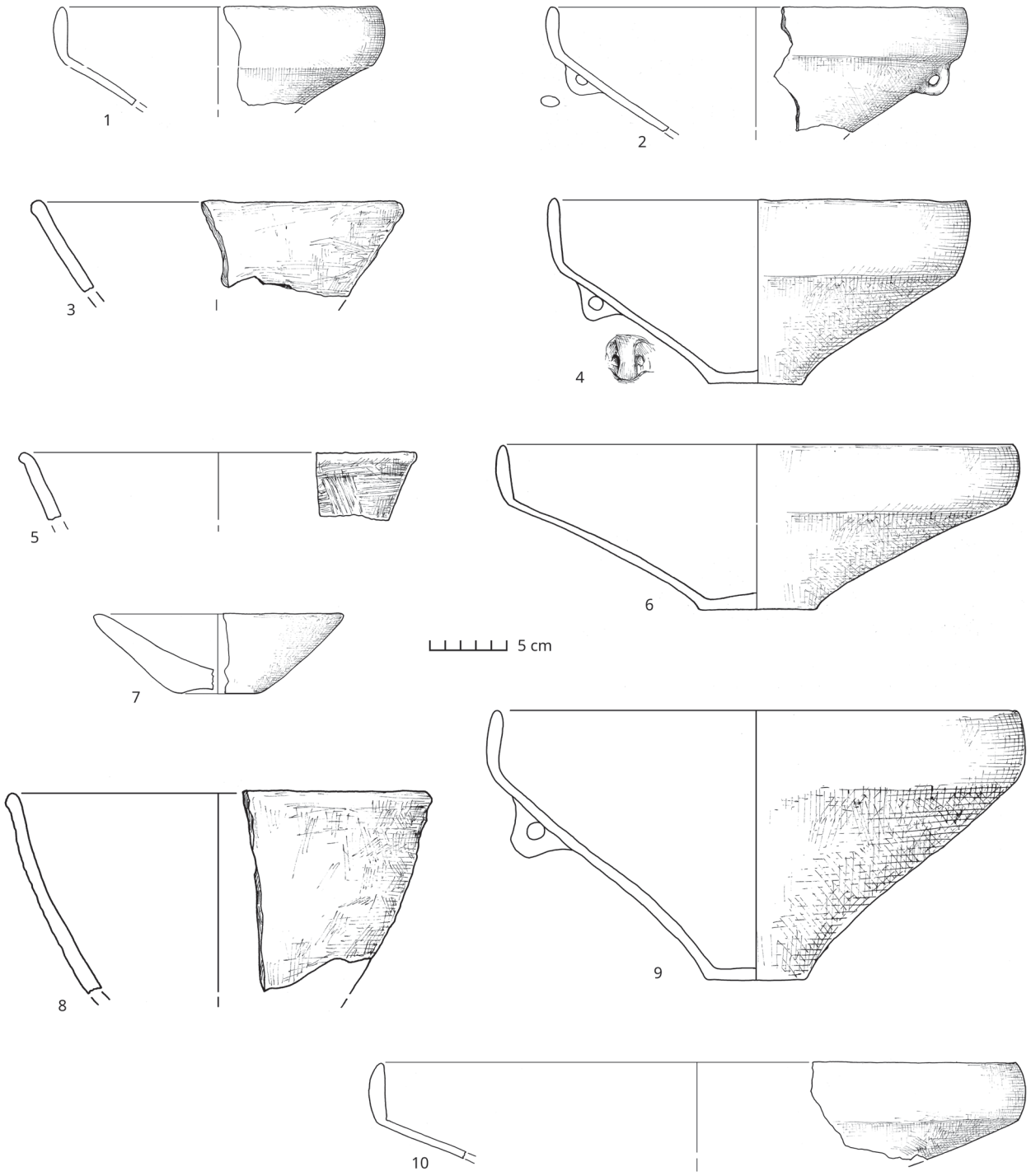


Fig. 19. Late Chalcolithic ceramics from the settlement in the harbour of Sozopol, excavation of the Centre of Underwater Archaeology in 1988, 1990, 1993 (drawings by N. Todorova, G. Mladenova, V. Petrova).

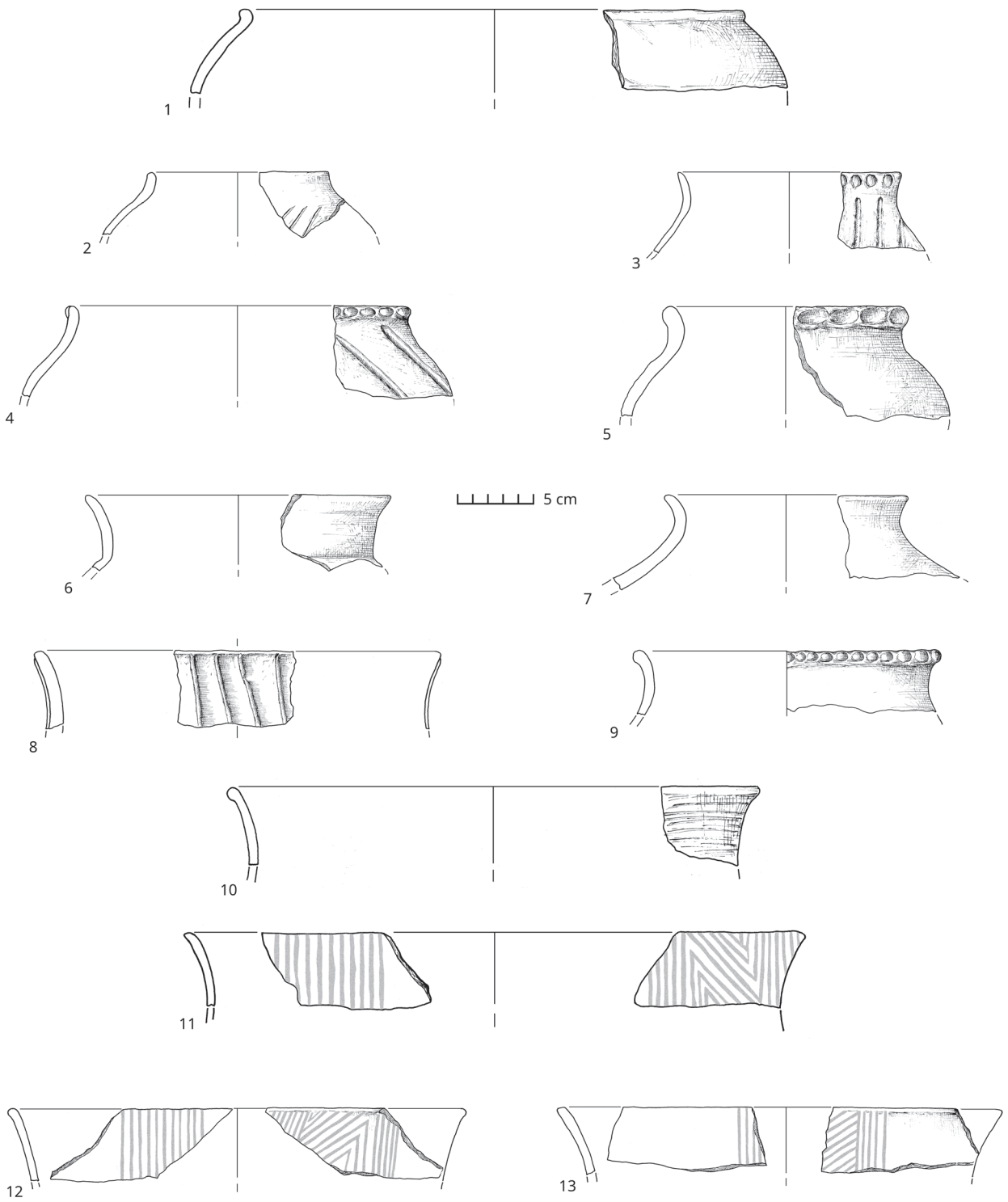


Fig. 20. Late Chalcolithic ceramics from the settlement in the harbour of Sozopol, excavation of the Centre of Underwater Archaeology in 1988, 1990, 1993 (drawings by N. Todorova, G. Mladenova, V. Petrova).

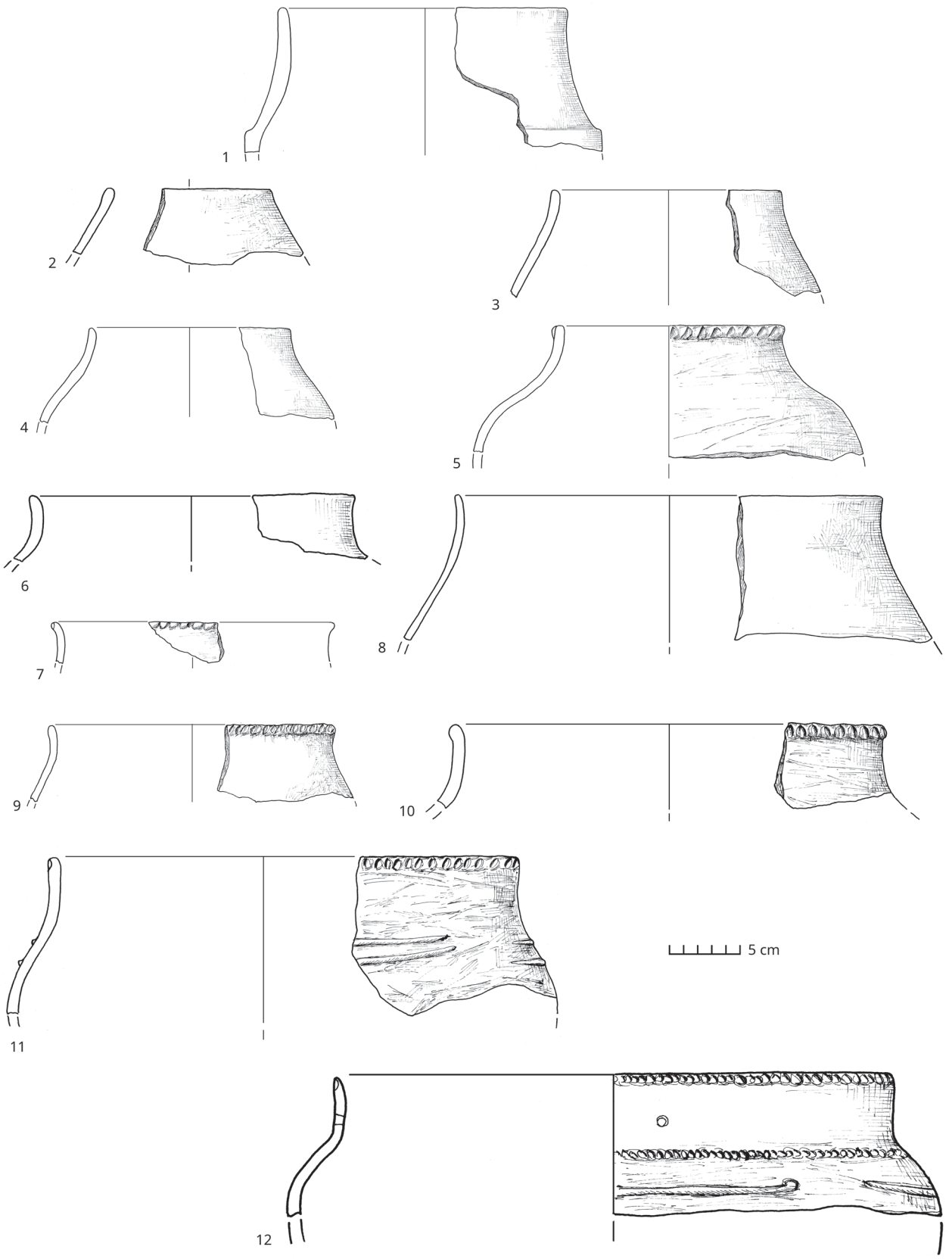


Fig. 21. Late Chalcolithic ceramics from the settlement in the harbour of Sozopol, excavation of the Centre of Underwater Archaeology in 1988, 1990, 1993 (drawings by N. Todorova, G. Mladenova, V. Petrova).

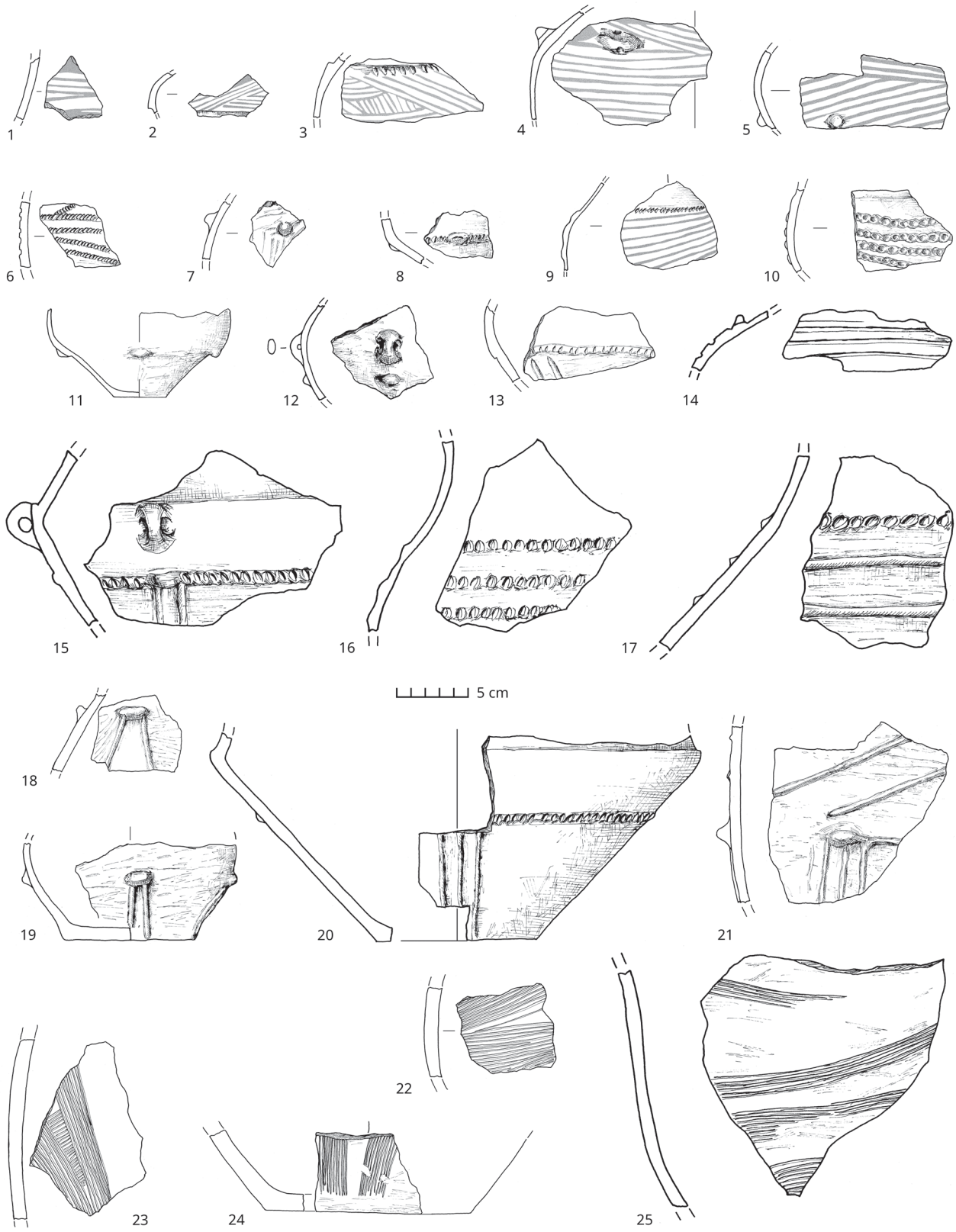


Fig. 22. Late Chalcolithic ceramics from the settlement in the harbour of Sozopol, excavation of the Centre of Underwater Archaeology in 1988, 1990, 1993 (drawings by N. Todorova, G. Mladenova, V. Petrova).

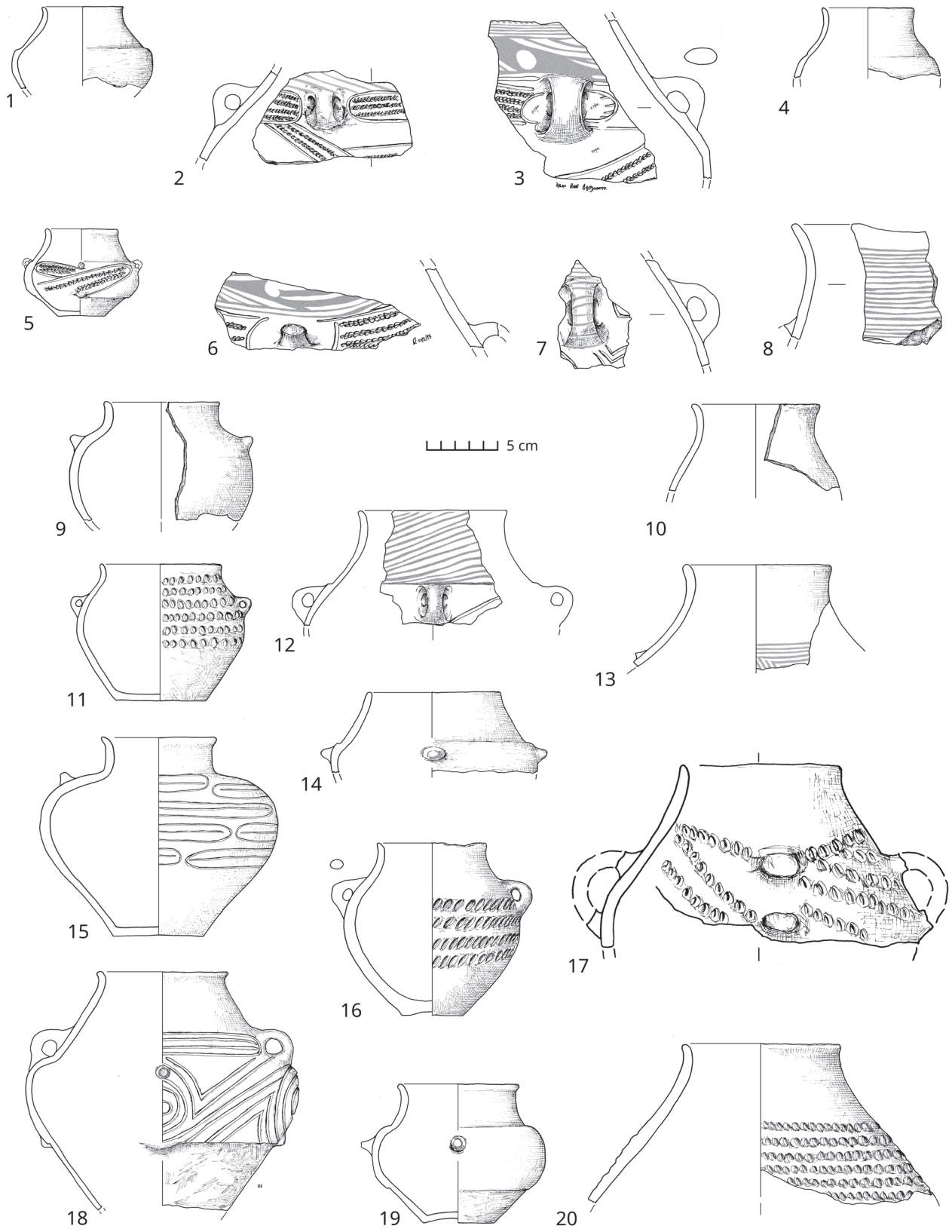


Fig. 23. Late Chalcolithic ceramics from the settlement in the harbour of Sozopol, excavation of the Centre of Underwater Archaeology in 1988, 1990, 1993 (drawings by N. Todorova, G. Mladenova, V. Petrova).

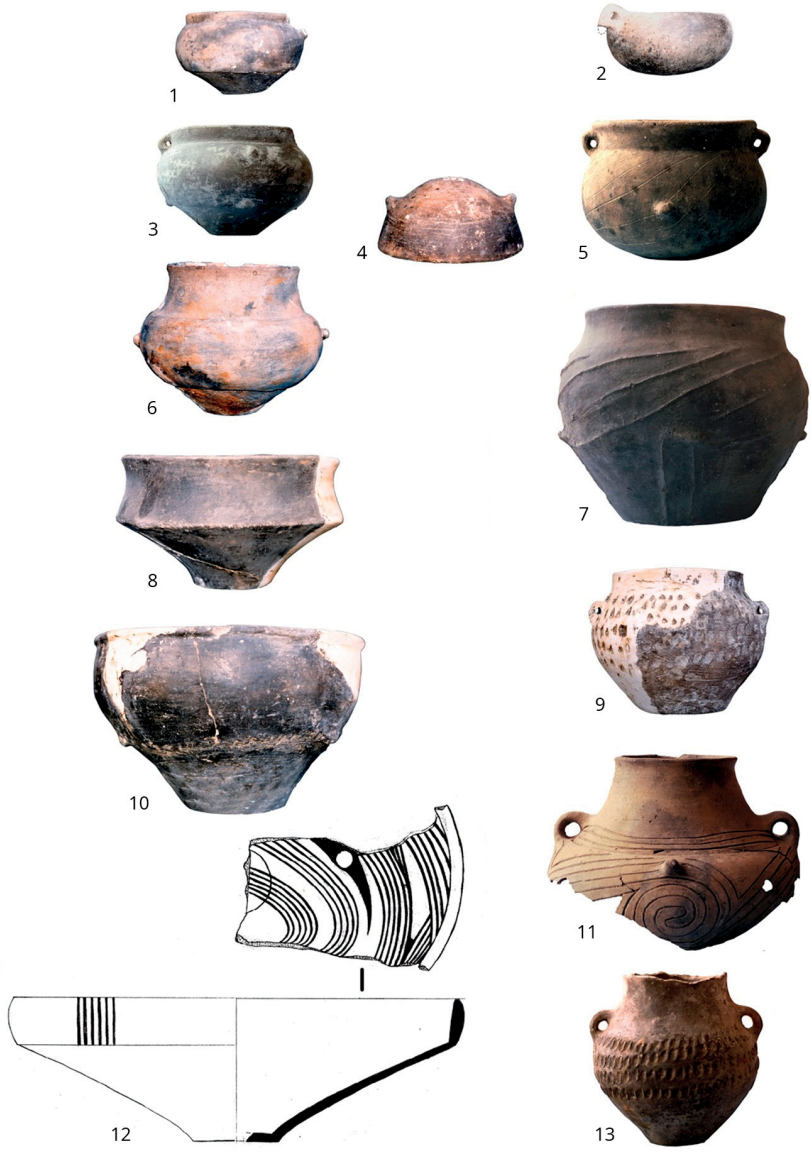


Fig. 24. Late Chalcolithic ceramics from the settlement in the harbour of Sozopol, excavation of the Centre of Underwater Archaeology in 1988, 1990, 1993.

The vessels without decoration prevail although all the techniques of decoration known during the Late Copper Age are present: incision, piercing, scratching, stamping, inlay, painting with graphite and paste-like white and red dyes, decoration with relief bands, buds and tongues, fluting and barbotine. Among the relief decoration, the bands of triangular section terminating in buds are the most common ones. Fluting appears seldom and is only horizontal. Except the dishes, all categories of vessels bear incised decoration. Straight horizontal, inclined or oblique lines are the most common patterns. The inlays appear on cups, jugs and lids. The pots, cups with round bottoms and conical bowls display notches. Stamped decoration is present mainly on jugs. Graphite painting appears on the inner side of conical dishes and on the outer side of bowls and cups. Relief decoration prevails on bowls, pots and jars (larger and rougher shapes). Decoration of the lids seems to repeat the one on the body of vessel.

Some of the fragments display traces of red and white paste-like paint applied to the visible surface of the vessel. We have to bear in mind that this type of decoration is of a special importance from a chronological point of view but it survives badly, the paint is washed very easily during excavations; although single painted fragments are found in cabinet processing, the type is really much more common than registered fragments. Usually traces of paste-like painting appear on vessels with a rich graphite decoration.

Often the vessels bear deliberately roughened fields on the lower part alternating with fine

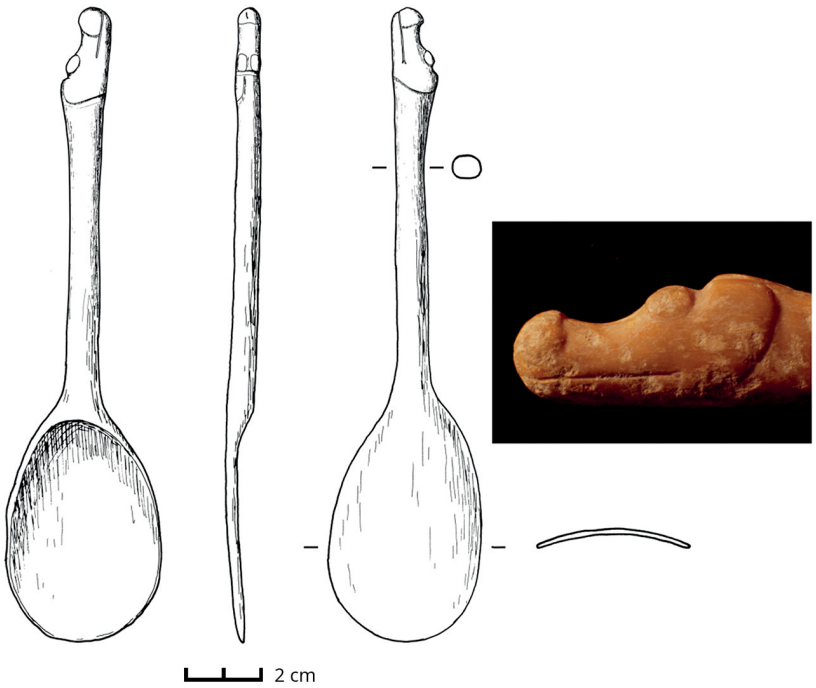


Fig. 25. Bone spoon with zoomorphic 'sceptre type' decoration, Late Chalcolithic layer of the settlement in the harbour of Sozopol.

burnished bands thus creating a complete composition. We have to note also the presence of certain archaic elements within the pottery complex from the Late Copper Age in Sozopol as deeply incised decoration with inlays forming meander-like patterns or deeply pierced fields or bands.

The ceramic complex from Sozopol displays a series of regional features alongside some new elements which relate it to the Final Chalcolithic or approximately 4100 to 3850 BC.[3] Supporting a generally later date than early 4th mill. BC we can also point out to some specific artefacts as the bone spoon decorated with a zoomorphic head of a type similar to the one on the stone sceptres, a ceramic altar with eyes and a zoomorphic figurine (*fig. 25*) (Dimitrov 2007, 145–158). In conclusion we can say that the Copper Age layer in Sozopol is one of the latest in date phenomena of the period not only along the seashore but also in a larger area. The exact chronological position of the Sozopol Late Chalcolithic site will be clarified after a complete publication of the materials from Atia and by a relevant comparative study.

3 A series of dendrochronological samples coming from quadrant D in Sozopol have been studied. They form 224 years of chronology. The latest samples are dating AMS ^{14}C from 4140 BC ± 19 (Kuniholm et al. 2007, 487).

Sector Sozopol 2

In the zone of sector Sozopol 2 the sea bottom is at a depth of 5m to 5.1m. Layer 1 is the same as in sector Sozopol 1 but containing numerous artefacts from the EBA.

Layer 2 is 0.40m to 0.45m thick. It encloses a great concentration of decomposed organic material. Its upper surface is flat indicating its formation in relatively calm waters. The layer contains archaeological debris of a settlement from the end of the first phase of the EBA (3000 to 2800 BC). The finds are pottery, animal bones and wooden constructions from houses; although numerous, they are not in situ. The artefacts are concentrated mainly in the upper ten centimetres of the layer. In the course of excavations displaced remains of wooden platforms have been registered. The remains of structures found suggest the houses were built over wooden platforms rising about 0.70m to 0.90m above the terrain supported by many posts. The posts were pushed to a depth of ca. 1.6m to 1.7m in a manner that presumes they were set up at different times during repairs or other activities (Ангелова et al. 1994, 17; Draganov 1998, 215).

The next layer in depth bears the nature of a cultural hiatus. Its thickness varies in the different quadrants. In quadrant B it is 0.40m thick, and in quadrant F 0.80m. The variations in thickness are

due to the registered displacement of the ancient terrain. Chronologically the hiatus relates to the end of the transitional period and the formation stage of the EBA (Ангелова et al. 1994, 17). The layer has been accumulated in a water environment in the course of time when the terrain was flooded as a result of rising sea level (Draganov 1998, 215).

The following layer in sector Sozopol 2 repeats layer 4 in sector Sozopol 1: single archaeological artefacts from the Chalcolithic were found at a depth up to 1.4m to 1.6m from the surface of the sea bottom or ca. 6.5m from the sea level (Ангелова et al. 1994, 17–20; Draganov 1998, 214–218).

According to the general observations, the particular layers 1, 2 and 3 show periods of changes in the environment and related changes in habitation.

Remarkably, the pottery from Sozopol is fragmented to a much greater extent than from the rest of the EBA sites found underwater. We can look for an explanation of this fact in a longer stay of these artefacts within a mobile environment before they were finally buried and fixed by sedimentation. This condition of the pottery is also due to the large-scale dredging activities in Sozopol harbour in the course of decades and the severe mechanical destruction of the seabed.

The Bronze Age pottery from Sozopol is handmade although single fragments made on a slow potter's wheel also appear.[4] The clay employed is fine, with some inclusions of sand, broken shells, tiny pebbles and sporadically grog. The pots are well fired in all the thickness of the sherds although their surface displays spots testifying to firing in open fireplaces within uneven reductive/oxidation atmosphere and a direct contact of the pot surface with the fire.

The colours of the EBA pottery from Sozopol are in the grey and brown range although single vessels with a deep black surface colour also appear. Obviously, these colours were not specifically sought after but were obtained as a result of the firing technology, smoothing and inclusions added. The most common colour is grey with variations from lighter to darker grey. Around the largest diameter of the pots with this colour black spots often appear and their surface is smoothed more roughly. Second come the pots with light brown surface well smoothed. Their fracture is grey-brown in colour displaying inclusions of sand, broken shells and small pebbles. The most common decoration of the pots of this colour are prints made with mussel shells at the upper sector of the body. Pots of prevailing grey colour of the outer surface and light brown spots or vice versa are present comparatively often. Vessels of black well smoothed outer surface are the rarest. Usually they are decorated with relief or pit like patterns.

The pottery surface ranges from fairly well smoothed to medium rough. Finely burnished surfaces are exceptions. The inner surface is carefully smoothed for functional reasons and its colour is darker than the outside one.

The main shapes characterising the pottery complex from the EBA in Sozopol are pitchers, pots, bowls and dishes of various sizes (*fig. 26–27*). Although small in number, the askoi and askos-like vessels come among the most peculiar shapes in the settlement.

Some of the vessels from the EBA in Sozopol have handles. The band-like handles of the pitchers with a high rim turned outwards are the most common ones. Less frequent are the band-like horizontal handles of a smaller size. Flat embossed buds rising above the mouth appear relatively often; besides their decorative function they might have a practical use as handles. Horizontal tunnel-like handles of a small size appear seldom under the mouth. Tunnel-like handles above the mouth rim are also known.

Most vessels have flat bases. The broad bowls of medium sizes appear seldom. Their bases are on low pedestals smoothly passing into the shape of the vessel.

The decoration of the Sozopol pottery is limited to the following kinds: pierced/stamped, incised and embossed patterns. Often the upper part of the pitcher's mouths show an ornament made with roughly twisted cord. Some types of vessels display also combinations of all kinds of decoration mentioned above. Incised decoration filled with white slip appears seldom. In most of the

4 It is possible that the fragments bearing traces of work on a slow potter's wheel are intrusive to the EBA complexes relating to later phases of the Bronze Age and coming from destroyed archaeological structures.

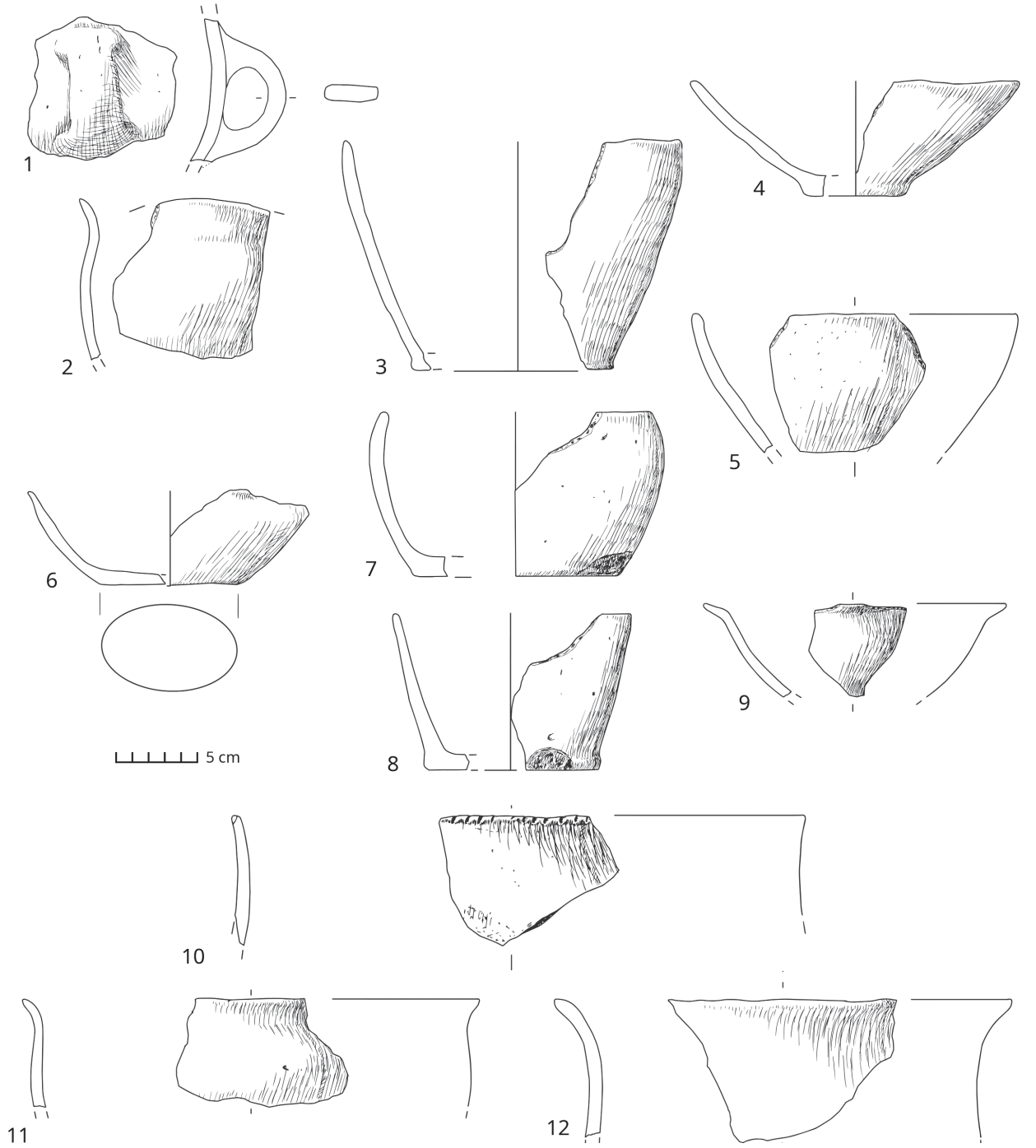


Fig. 26. Early Bronze Age ceramics from the settlement in the harbour of Sozopol (drawings by H. Vasileva).

cases the decoration runs along the rim or under the mouth as well as along the transition from the neck to body of the pot.

The 'pierced' patterns have been made with various tools: shells, bone awls or other similar ones. It seems that the stamped decoration made with a twisted cord is a variant of the pierced one using a specialised tool. The pierced decoration appears mostly along the mouth rim of pitchers with vertical band-like handles. We find it also on the bowls of smaller size and a rough outer surface. The stamped patterns made with a twisted cord on small bowls are composed of isosceles triangles pointing their tops down and filled with white slip. Most of the askos-like vessels are also decorated with pierced or stamped patterns not always arranged in a regular horizontal line along the transition from the neck to the body. Usually

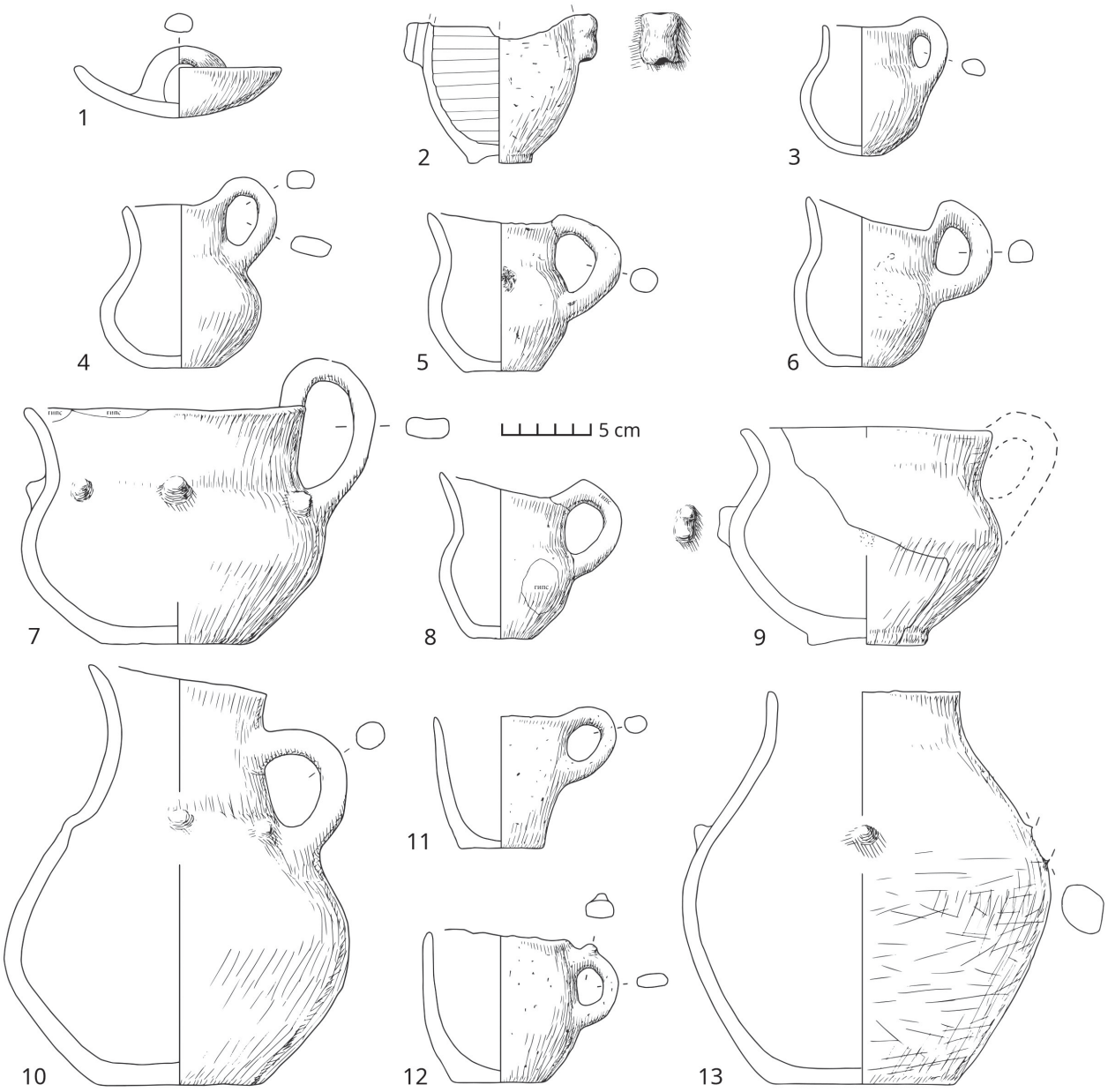


Fig. 27. Early Bronze Age ceramics from the settlement in the harbour of Sozopol (drawings by H. Vasileva).

the ornament is running along the shoulder at the lower end of the handle.

The embossed decoration is also broadly employed. It is composed of relief bands with fingertip imprints fixed under the mouth of the vessels. They appear also on the walls of vessels on low pedestal. A variation of this kind of decoration are embossed elongated buds arranged obliquely right under the mouth of the vessels. The embossed decoration appears also as a combination of both kinds as well as in the variant of combination of embossed and pierced patterns or embossed and incised ones. In most of the cases the relief pinched bands are fixed along the outer rim of the mouth and the pierced patterns on the walls of the vessels. Often a similar decoration appears also along the side edges of the high vertical band-like handles. Pit like imprints made with the tip of the fingers have been also applied as decoration. They are usually arranged in a single horizontal line under the mouth as well as on the walls along the largest diameter of the vessel. The pits like finger impressions appear also in a combination with pierced patterns on the body of the vessels.

The most and closest parallels to the pottery from the EBA from the Sozopol harbour are known

from horizon IIA in the EBA settlement Golemiyat Ostrov (The Big Island) in Durankulak Lake, the earlier phases of Ezerovo, horizon I and II, and Dyadovo. General parallels of the shapes and some kinds of the decoration come also with the pottery from EBA from Kiten; however, we have to note that the classical type of cord-decoration is missing entirely in Sozopol while in Kiten it is a main chronological diagnostic element.

Some elements of the pottery complex (for instance, the tunnel-like and pseudo-tunnel-like handles and certain kinds of hemispherical pots) point to parallels with Ostrovul Corbului, Glina IV relating to the late EBA 2 and the transition to EBA 3. Having in mind the limited comparative material from the settlement at bay in front of Ropotamo River estuary, we can say that the pottery from the EBA from both Sozopol and Ropotamo is similar and probably from the same time.

On the basis of available materials and finds we can affirm that the settlements from the EBA in Sozopol, Ropotamo, Ezerovo and Durankulak belong to a synchronous horizon from the same age specific for the western Black Sea coast. This complex (Durankulak IIA, Sozopol II and Ezerovo) should be related to the early second phase of the EBA and the very beginning of third phase (EBA 2b.c) and dated from ca. 2700 to 2100 calBC. The next stage of this horizon is at the border between the finale of EBA 2 and EBA 3 (2700 BC/1800 calBC) and is represented by the submerged EBA settlement Urdoviza near the town of Kiten. The general difference between EBA in Sozopol, Durankulak IIA, and Ezerovo on the one hand and the settlement in Kiten on the other is the affiliation of the complexes. The first group of sites are in relations with the cultural complex of Cernavodă III, while the Kiten settlement is a typical representative of the cultures influenced by Cernavodă II.

Sector Sozopol 3

It is located southeast of sector Sozopol 2. Sozopol 3 contains traces of a settlement from the Early Iron Age entirely destroyed (*fig. 10.3*) (Angelova et al. 1995, 54 f.).

Alongside these three sectors archaeologically explored, prehistoric materials have been discovered in the western sector of the bay, next to the seashore of St. Kirik Island, close to the wharf of the Border Police, but they have not yet been studied in more details.

In parallel with the archaeological excavations in Sozopol, large interdisciplinary research has been also carried out. The aim of these studies is to clarify the palaeo-ecological and palaeo-geographical environment of the settlements from the LCA and the EBA.

The palynological studies of samples from the harbour are on two sets of samples from sectors Sozopol 1 and Sozopol 2.[5] In analyses the micropalynological material has been divided into four chronological zones (segments of the excavation heap) corresponding to the clearly distinguished phases of the change in the environment registered stratigraphically in the heaps (Filipova-Marinova et al. 2011, 230–244).

In connection with the palynological studies, ^{14}C dating of three carbon samples has been also accomplished. The samples come from the layers containing the most numerous traces of human activities: two from the probe in quadrant I and one from quadrant D.[6] The dates from quadrant I are 3227 calBC and 3979 calBC, and from quadrant D 4139 calBC.

The first chronological zone (represented only in the trenches in quadrant D), corresponding to the earliest explored period (the lowest levels of the excavation heaps), shows prevailing dense oak forests (*Quercus*) with the presence also of tree species as hazel (*Corylus*), hornbeam (*Carpinus*), etc. The pollen of grain plants registered we have to associate with wild species rather than cultivated

5 In quadrant D, depth of sea bottom 4.3m to 4.6m, coordinates 42025'85 N, 27041'88 E, length of the probe 2.1m. In quadrant I, depth of the sea bottom 5.0m to 5.1m, coordinates 42025'88 N, 27041'44 E, length of the probe 1.9m.

6 The analyses of the carbon samples from quadrant I have been accomplished in Woods Hole Oceanographic Institute, and of the one from quadrant D in the VERA laboratory of the Vienna University, data after (Filipova-Marinova et al. 2011, 234):

Lab-Code	Depth (cm)	^{14}C date BP	CalBC	Material
Sz-I/OS-58077	35–45	4560±40	3227	Charcoal
Sz-I/OS-57882	155–165	5170±30	3979	Charcoal
Sz-D/VERA-1652	65–70	5130±40	4139	Unburned wood

plants. The climate was warm and humid. The amount of micro-coals is minor due to the lack of human activity and interference with the environment (Filipova-Marinova et al. 2011, 237).

The second chronological zone (found out in all three probes) represents the habitation in the Late Copper Age. Two of ^{14}C dates, 4139 calBC and 3979 calBC, belong to it. In this zone the woody flora was less than in the first zone (38.7%). The most common tree species were oak, beech (*Fagus*), elm (*Ulmus*), lime tree (*Tilia*), hornbeam (*Carpinus betulus*), hazel (*Corylus*), etc. The pollen comes from the forests around the settlement as well as from more remote regions of the Strandzha mountain. The second zone corresponds to a period of climate optimum, with higher temperatures and humidity which has been determined by the presence of liana species (*Hedera*, *Humulus*, etc.). The climate was favourable to forest development; however, this contrasts with the lower amount of pollen of deciduous tree species due to the anthropogenic deforestation in the area of the Late Chalcolithic settlement. The settlement was located close to a fresh water basin related probably with the Patovska river or swamps and a *liman* along its lower flow. The soil in the region of the settlement was humid, rich in humus and fit for farming. Well-presented cereal pollen suggests an intensive agriculture. Wheat (*Tritica*) and barley (*Hordea*) species might have been cultivated. The arable farming is also proven by the presence of weeds associated with the cultivation of the fields. Pollen of ruderal species testifies to meadows and is associated with livestock farms. This zone also contains the highest registered concentration of micro-coal testifying to deforestation and opening up areas for agriculture by burning forests (Filipova-Marinova et al. 2011, 237–240).

The next chronological zone is from the ditch in quadrant I. It is divided into two sub-zones. Here we can again observe an increase in the amount of tree species pollen. The growth of forests was associated with favourable climate conditions: high temperatures and an increased humidity. The forests were oak with the presence of some other tree species as hornbeam (*Carpinus betulus*), lime tree (*Tilia*), elm (*Ulmus*), ivy (*Herdera*), ash (*Fraxinus*), etc. The pollen of herbaceous plants is of a low percentage suggesting the forest vegetation prevailed. The notable increase of pollen from hornbeam and other species (such as birch) in the Strandzha mountain and along the southern coast of the Black Sea has been explained with changes in climate. The sharp decline in pollen of cereals shows a lack of farming and probably of permanent human habitation. The presence of cysts of brachial dinoflagellates resistant to variable salinity of the water testifies to a brachial environment and an active contact zone between a fresh water basin and the sea. This circumstance is further proven by plankton diatoms and the replacement of clay sediments with terragenic origin created by land erosion, abrasion and accumulation of sands, gravel and alluvium. The reasons for changes in the landscape and the environment were climatic alternation and rising sea level (Filipova-Marinova et al. 2011, 240 f.).

The fourth zone has been found only in the sample from quadrant I. The pollen ensemble shows a serious change of climate associated with the beginning of the Sub-boreal climatic period. The amount of tree pollen decreases and that of cereals increases. This shift is explained not only by climatic changes but by human activities as well. The main agricultural crops were wheat (*Triticum*) and barley (*Hordeum*). The high percentage of pollen from meadow and ruderal species shows a developed stock breeding and the appearance of pastures and forest glades. The lower percentage of cysts of dinoflagellates is due to a decrease of the relative sea level and the transformation of the region of today's Sozopol harbour into dry land once again (Filipova-Marinova et al. 2011, 241).

The change of the environment and its interrelation with human activity in the region of the prehistoric settlements in Sozopol harbour have been analysed also by studies of microfossils from two ditches in quadrants F and D. The probe in quadrant F is 1.8m long taking 18 samples, one for every 0.1m. In a synthesised and generalised form, the microfossils analyses in a chronological and stratigraphic order from bottom to top show a transition from fresh water to brackish and salt-water basin. The data – especially in comparison with the stratigraphic observations – support and refine the proposed reconstruction of the landscape in the region of the prehistoric settlements in Sozopol harbour (Ognjanova-Rumenova

2008, 291 f.; Ognjanova-Rumenova/Zaprjanova 1998a, 65–80; 1998b, 39–50).

One of the main conclusions after processing the osteological material from the submerged settlements in Sozopol harbour concerns the impressive domination of wild animals over domestic ones. This is valid for the settlement from the LCA as well as for the one from the EBA. Calculated for both periods, in Sozopol the percent ratio of wildlife to domestic animals is 77.45% to 22.45% according to the number of bones, and 69.16% to 30.84% according to the number of animal species (Spassov/Iliev 1997, 300–302). Obviously for the inhabitants of Sozopol settlements hunting was of primary importance. Alongside large ungulates – red deer, aurochs (*Bos taurus primigenius*) and fallow deer – they also hunted small animals – fox, lynx and badger – perhaps for their fur (Spassov/Iliev 1997, 289–297; Ribarov 1994, 52). A curious find among the LCA material are the bones of a lion (Spassov/Iliev 1997, 290; Ribarov 1994, 53).

Among the important osteological observations we have to note the large amount of bones of dolphins coming mainly from the settlement from the EBA. By number of individuals they rank at the second position within the mammal group (after the red deer) and testify to the possibilities of people to go out into the open sea employing fishing nets and/or harpoons (Spassov/Iliev 1997, 291). Bones of tuna fish (*Thunnus thunnus*) and of belted bonito and turbot also illustrate skills for fishing and seafaring. Alongside bones of wild animals, domestic ones are present. Nevertheless, livestock farming has not been well developed to be a major source of food and furs (Spassov/Iliev 1997, 299 f.).

The large amount of wild animals suggests the existing of vast forests in the vicinity of the settlements in Sozopol. The identification of bones of a lion and fallow deer testifies to open spaces at least during the Copper Age. There were fresh water basins nearby the settlement, habitats of water turtles and birds. During the Late Chalcolithic the weather was warm and humid. Probably the winters were mild and the snow cover was held for a short time. The changes in the distribution of different species suggest that at the beginning of the Bronze Age the climate became cooler and dry. According to the osteologists, the decrease of the population of fallow deer during the EBA was a result of climatic changes rather than of people's hunting it (Spassov/Iliev 1997, 300; Ribarov 1994, 52).



Fig. 28. Heavily corroded copper axe from the Chalcolithic settlement in the harbour of Sozopol.

Artefacts from Sozopol Associated with Metallurgy and Metal Extraction

In the course of underwater research in Sozopol in 1986/1987 a heavily corroded flat copper axe (*fig. 28*) was found. Due to a long stay in aggressive marine environment and chemically active sediments, the degree of deterioration is very high and the precise typological affiliation of the piece is hard to determine. In general, it can be related to the medium size flat copper axes from the Late Chalcolithic. The material the axe has been made of is entirely mineralised and unfit to chemical analysis of the composition and specification of the lead-isotopic relations (Pernicka et al. 1997, 73).



Fig. 29. Crucible fragments from the settlements in the harbour of Sozopol: 1–3 Chalcolithic, 4 Early Bronze Age.

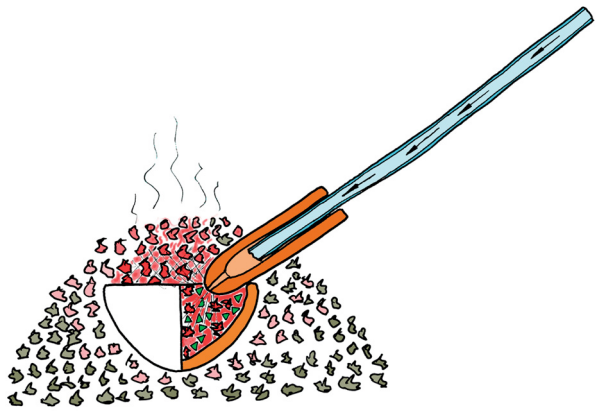


Fig. 30. Reconstruction of the crucible operation way based on the observations on the fragments from the harbour of Sozopol.

While studying the archaeological artefacts from the 1986/1987 and 1990 underwater research in Sozopol a couple of pottery fragments from the Late Chalcolithic and the Bronze Age were identified which can be associated with metallurgical activities.

The fragments from the Late Copper Age (three pieces in total) are dark grey in colour (*fig. 29: 1–3*). The clay they have been made of is well purified, with inclusions of fine sand and traces of fine organic material. Two of the fragments have their mouths preserved, and the third one belongs to the wall of a shallow vessel of medium size. By colour, thickness, clay composition and surface they do not differ significantly from the rest of the Late Chalcolithic pottery from Sozopol.[7] The features that distinguished them from the rest of the pottery are the prominent traces of heavy heating around the mouth as there the fragments are partially glazed, poriferous and deformed. This heating has resulted in their very low weight as well. Two of them bear also tiny drops of copper (smaller than 1mm) incrusted in the pieces and oxidised to green. According to its appearance, the vessel originally might have been used for a metallurgical process (extracting, refining or melting) of copper. For that reason, we can define it as a metallurgical crucible. The arrangement of the traces from heating shows that the highest temperature was reaching the inner side at the highest sector

7 All three fragments display similar features (clay composition, colour, thickness, surface and general shape); thus it seems possible that they belonged to the same vessel but we cannot reconstruct it.

Comparative feature	Late Copper Age pot	Early Bronze Age pot
Material	Usual clay for table pottery	Rough and sandy with thick quartz sand, chaff and weakly binding clay; specialized heat-resistant clay
Baking	Uneven, locally heated mouth, glazed and deformed. The clay is not resistant to heating	Evenly baked; heat-resistant clay
Shape of the pot	Shallow pot with a round bottom	Cone-shaped, with a flat thick bottom on foot
Traces of oxidized metal	On the mouth	On the bottom

Table 2. Comparison between Late Copper Age and Early Bronze Age pottery from the site.

of the crucible, near the mouth. The traces (glazing and shape deformation) can be obtained in front of bellows put on top to blow charcoal with a snout directed to the centre and the bottom of the vessel as the latter is not fully heated at this high temperature (*fig. 30*). As mentioned above, the crucible has been made of fabric common of the pottery from the settlement which was obviously not resistant enough to function as a vessel for high temperature use. We can see this also by the use of a normal pot for metallurgical work. The shape and size of the crucible from the Sozopol Copper Age settlement cannot be reconstructed precisely; however, its base is rounded, round or elliptical in shape and probably very similar to the one found in pit 28 in Akladi Cheiri (Лещаков/Класнаков 2010, 58–61). Probably during the Copper Age all metallurgical processes were conducted in open pits below a pile of charcoal as evidenced by the traces of heating.

The fragments from the EBA that can be associated with metallurgical activities have been made of rough and friable sandy clay mixed with very coarse sand and chaff. They come from a vessel with a wide-open mouth and a flat and thick base over a thick foot; particles of oxidised metal are attached to its inner side (*fig. 29: 4*). We can identify the vessel as a crucible according to three features: specific sandy composition of the clay, which is resistant to heating and entirely different from the clay the other vessels have been made of in the settlement from the EBA; traces of heating at high temperature probably in a kiln or a larger metallurgical structure; presence of oxidised metal inside. Comparing the Bronze Age crucible with the one from the Chalcolithic Age, we can observe significant technological differences due to the different functions of both crucible and/or the different tradition and stage of mastering metalworking and metal extracting technologies (*table 2*).

The crucibles from Sozopol testify to practicing small-scale works in the settlement itself: the melting and/or refining metal.

Conclusion on the Submerged Prehistoric Settlements in Sozopol Harbour

Both vertical and horizontal stratigraphy shows that in the aquatory of Sozopol harbour two prehistoric settlements existed: one belonging to the Late (Final) Copper Age and another one from the EBA. They are situated close to each other overlapping partially, in sector Sozopol 2. It has not been determined if the EBA layer continued in sector Sozopol 1 as well where it was destroyed and removed by dredging and cleaning works in the port carried out a couple of times during the 20th cent. AD.[8]

The research in 1990 and 1993 revealed that the Late Chalcolithic settlement was located on a non-flooded (river) terrace and the one from the

8 In 1993, during archaeological surveys in the aquatory of Sozopol, numerous prehistoric artefacts were discovered lying on the seabed over an area of ca. 1000m^2, in a zone about 500m southeast of St. Kirik Island, 11.5m to 12m deep (Димитров/Аврамова 1994, 20; Димитров et al. 1995, 32 f.). The excavations carried out there showed that the presence of the artefacts at this depth and spot is a result of dumping of dredged material from Sozopol harbour (removed and thrown behind St. Kirik and Yulita Islands) (Ангелова et al. 1996, 113).

EBA on a terrace probably periodically flooded or humid; for that reason the EBA houses were constructed over wooden platforms (Angelova et al. 1995, 54 f.).

The Late Chalcolithic settlement existed at the very end of the 5th and in the early 4th mill. BC. The pottery relates it to the end of the Late Copper Age and the transitional period to the EBA, between the end of Varna III (4000 BC) and the first phase of Cernavodă I (Draganov 1995, 236) or Cernavodă III in the region of Dobrudzha (3850 BC) (Angelova/Draganov 2003, 21). The Chalcolithic sites in Sozopol and Atia (as far as the material from the latter is known) can be distinguished as the latest southern variant of Varna culture (Varna IV) which existed after the end of a series of settlements from the Late Copper Age in Thrace or around the Varna lakes.

It seems that the Late Chalcolithic settlement was ruined in fire and soon afterwards flooded. We have to associate this event with the New-Black Sea transgression during the late 5th and the mid-4th mill. BC. The change of the sea level resulted in formation of a *liman* and swamping the area of today's Sozopol port due to groundwater rise and the constant flow of the Patovska river and other streams existing in the past (Draganov 1998, 214–218). During this period the upper levels of the Chalcolithic layer were destroyed in a water-logged environment. Subsequently the layer of hiatus found in sector Sozopol 2 was accumulated (Draganov 1998, 215). In the mid-4th mill. BC the New-Black Sea regression began to open again new territories where a settlement from the EBA emerged. It was constructed over wooden platforms due to high groundwater. The settlement existed for a period of about 150 to 200 years. It is synchronous to the horizons VI–V of Ezero or even the earlier horizons VIII–IX of the same site (Draganov 1995, 236). This settlement was also destroyed in a fire. Its remains were flooded during the New-Black Sea transgression when the region was once again under water. The next period of the geological development of the Black Sea is the Phanagorian regression when the sea again withdrew giving the chance to a settlement of the Early Iron Age to emerge along the coast of Sozopol bay (Ангелова et al. 1994, 17–20; Draganov 1998, 214–218). Archaeological research reveals that the regression and transgression phases of the sea change the landscape of Sozopol bay. During transgressions the dry and non-flooded terraces turn initially into swamps and *limans* and afterwards into bays, and vice versa. During regressions the sea bays turn into *limans* and swamps, and then again into terraces.

5. Alepu

Alepu lagoon is situated at the foot of the Medni Rid mountain chain between the promontories Sveta Agalina and Sveti Toma, the southern one separating the bay from the Ropotamo estuary. It is about 3km long and 100m to 200m wide, oriented north/south and is connected to the sea by a narrow channel north of the spit.

In March 2012 during coring fieldwork at the northern shores of the Alepu lagoon (at the edge of the water body) an archaeological site was discovered: three vertical oak piles, ca. 1m long, were retrieved from the core gouge, with part of their bark still preserved. Above the pile, an assemblage of charcoal, seeds, fish and shell remains, bone fragments and some lithic fragments and potsherds were identified (Flaux et al. 2016, 57–70). The piles lie 5.8m to 6.8m below the sea level. The thickness of the archaeological layer is 160 ± 20mm. The archaeological team that discovered the site and analysed the cores supposed that they found an EBA settlement (*fig. 31.1–31.3*). Five radiocarbon dates from wood fragments, charcoal and organic macro-remains constrain the age of the site to between 3350 and 3000 calBC. Based on the thickness of the archaeological layer a maximum occupation time of 80 ± 10 years was suggested. Both the lower and upper limits of the archaeological layer were sharp indicating from a sedimentological point of view, that the beginning and the end of occupation were not progressive nor discontinuous, but rather rapid and definitive. The vegetation assemblage illustrates temperate continental climate conditions. The charcoal remains confirm the use of oak tree as a dominant timber resource. Palaeobotanic remains highlight gathering activities and the consumption of wild grapes, raspberries and figs. The herbaceous assemblage evokes deforestation activities. Exploitation of coastal resources is

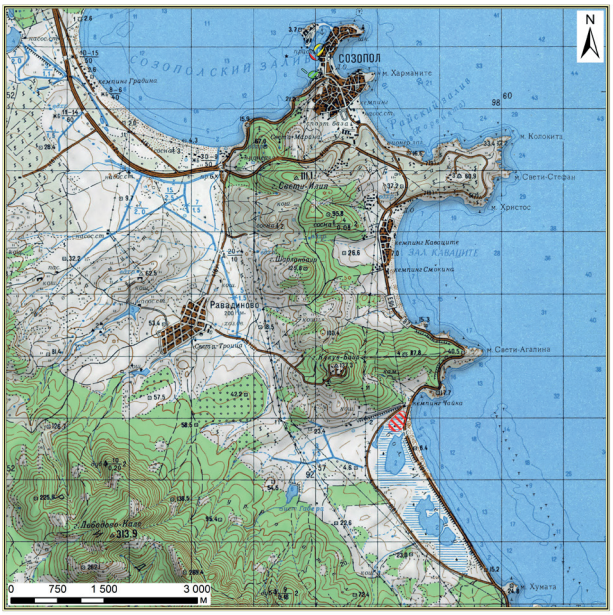


Fig. 31.1. Location of the coring in the Alepu lagoon, topographic map 1:50,000.

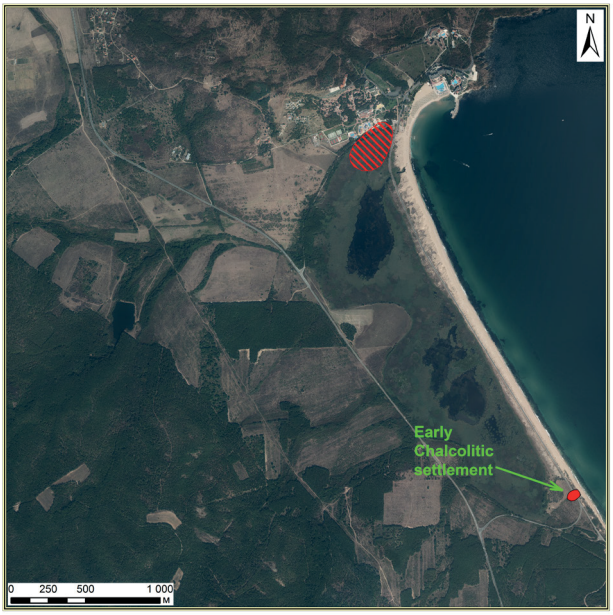


Fig. 31.2. Possible location of EBA settlement at the northern side of the Alepu lagoon, orthophoto image 2016. In the SE corner: location of the Early Chalcolithic settlement.

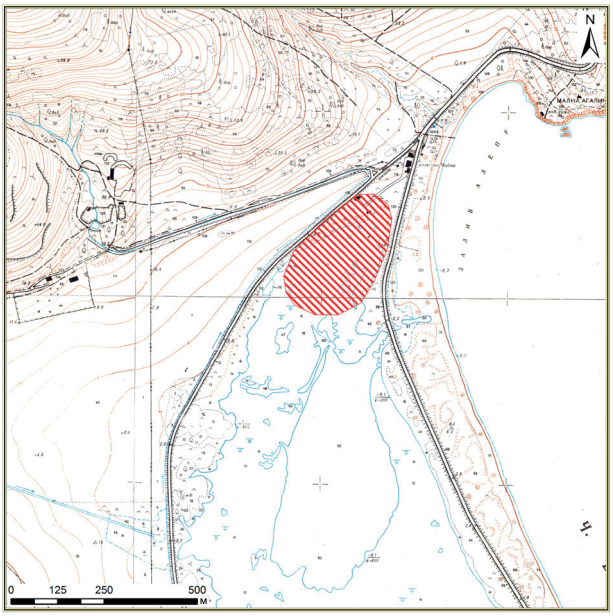


Fig. 31.3. Possible location of settlement at the northern side of the Alepu lagoon, topographic map 1:5,000.

well attested by the great density of fish remains, dominated by anchovy (61%), highlighting possible preservation of fish products. The small pottery fragments (< 1cm) found in the core are of dark brownish colour and more or less homogenous, made from a coarse clay well baked with many medium size inclusions of quartz. The surface does not show any traces of polishing.

According the research team the site was located at the edge of a protected lagoonal waterbody close to the sea level. A probable natural lagoonal harbour, providing anchorage facilities and a connection to the sea was another factor attractive for settling.

The retrieved core sequence was 6.85m long and comprises of two well-defined sedimentary facies. The lower is between 6.85m and 4m below the surface and comprises of dark grey silts and clays. It characterises a lagoonal environment lying behind a wide and high sand spit which isolated the lagoon from coastal hydrodynamics like today. The lagoonal muds were then buried by landward growth or the migration of sand dunes. The archaeological layer was deposited in this unit between 5.9m and 5.75m and was in the different cores between 14cm and 19cm thick. The lower and upper limits of this layer were well defined. The wood piles were cored and retrieved below the archaeological layer at the following depth ranges: 6.01m to 6.83m, 5.8m to 6.82m and 5.59m to 6.71m. They were fixed within the lagoon bottom sediments.

The upper one of the two sediment facies is a sand unit 4m thick its colour ranging between grey, light grey and yellow from the base towards the top with identical grain-size and equal distribution. It was deposited under aeolian dynamics which formed a dune.



Fig. 32. Floating crane 'Gigant' working in 1976, during the discovery of the site at the mouth of Ropotamo river, archive Ivan Karayotov.



Fig. 33.1. Location of the prehistoric site in the bay in front of the mouth of Ropotamo river, topographic map 1:50,000.



Fig. 33.2. Location of the prehistoric site in the bay in front of the mouth of Ropotamo river, orthophoto image from 1918. T 1 and T 2: archaeological trenches from the excavation in 2017.

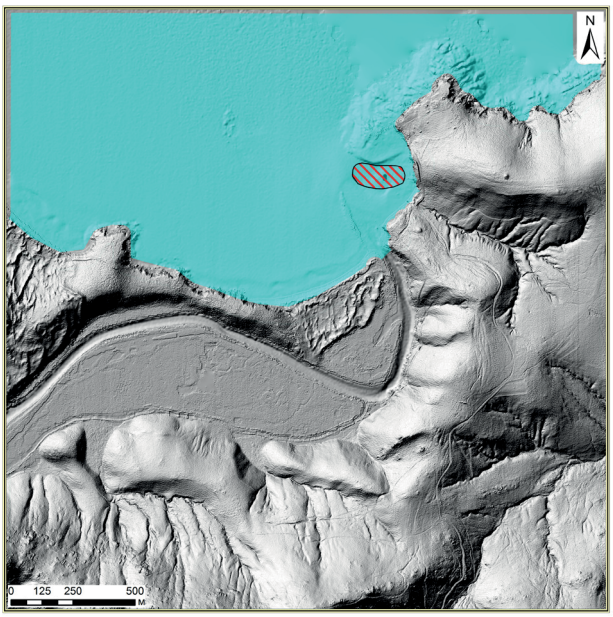


Fig. 33.3. Location of the prehistoric site in the bay in front of the mouth of Ropotamo river, bathymetric and land Lidar DTM model, project of the Centre of Underwater Archaeology 2009.

6. Ropotamo[9]

The first archaeological artefacts under water in the sea bay in front of Ropotamo estuary were discovered during dredging works by the 100t 'Gigant' floating crane in 1976 when deepening the bay to provide the possibility of docking ships with droughts of ca. 3m (*fig. 32*). In the course of 'Gigant's work, artefacts from late antiquity and the Middle Ages were found. Today some of them are housed in the Burgas and Varna Museums of Archaeology. Among them a rich collection of Late Roman red-varnish pottery is distinguished

9 From 2017 an archaeological excavation project of the Center of Underwater Archaeology has been conducted at the site Ropotamo. The actual article presents and discuss the site within the knowledge till 2017.



Fig. 34. Early Bronze Age ceramics from the prehistoric site in the bay in front of the mouth of Ropotamo river: 1 MAP Black Sea project excavation of 2017; 2 excavation of Ivan Karayotov from 1989 (drawings by D. Garbov and H. Vasileva).

(Mincev 1983, 194–201; Минчев 1982, 26–28, N14–25).

From 1982 to 1989 several archaeological underwater surveys and excavations campaigns were conducted (1985, 1986, 1989) in an attempt to trace the stratigraphy of the site (Карайотов 1984, 186–191; 1986, 192 f.; 1987a, 284 f.; 1987b, 357–360; Карайотов et al. 1989, 175 f.; Карайотов 1990, 178 f.). The excavations were carried out in the bay south of St. Dimitar Cape, about 150m from the shore (*fig. 33.1–33.3*) (Karayotov 1992, 277–280; 2002, 558–567; Карайотов 2012). Stratigraphic observations from the research in the period between 1982 and 1989 could be summarised as follows:

- **Layer 1.** From 0m (in 1980s the sea bottom was 3.5m deep below the sea surface in the explored zones) to 0.5m, a mixed layer containing sand and shells of sea and river mussels.
- **Layer 2.** From 0.5m to ca. 1m, a layer of stones.
- **Layer 3.** From 1m to ca. 2m, a layer containing mixed archaeological artefacts from the antiquity, late antiquity, Middle Ages and Ottoman Age. The layer is composed of pottery fragments, sand and trunks and branches drawn from the incoming waters of the river.
- **Layer 4.** The layer begins at a depth of ca. 2m (in the ground) marked by a layer of mussels. It is 0.1m to 0.3m thick. Layer 4 continues to ca. 4.0m depth, reached only in the quadrant explored in 1989. Only there the bedrock was hit.

Layer 4 is characterised by wooden posts 0.2m to 0.4m in diameter, fixed into the ground. In its upper part the layer is covered with alternating layers of shells and sand (0.1m to 0.3m each) with a total thickness of about 0.5m. The wooden posts pass through the section of shells and continue in depth. Below the shell section fragments from the EBA appeared. A corner of a building from the Bronze Age was revealed in depth, marked by two rows of posts placed at 1.0m distance and a fragment of floor daub. Below the daub a layer of fine river sand and pottery fragments were registered which I. Karayotov describes as drainage but probably it is a base of an oven. The posts were embedded in alluvium layer below the level of the drainage.

The prehistoric artefacts from the layer below the shells are two jugs from the EBA with round bodies and high handles as well as 2633 fragments of grey-black hand-made pottery from the Bronze Age (*fig. 34: 1*). Some of the fragments bear cord



Fig. 35.1. Location of the water well 'Kachkata' in Stomopolo Lagoon near Primorsko, topographic map 1:50,000.

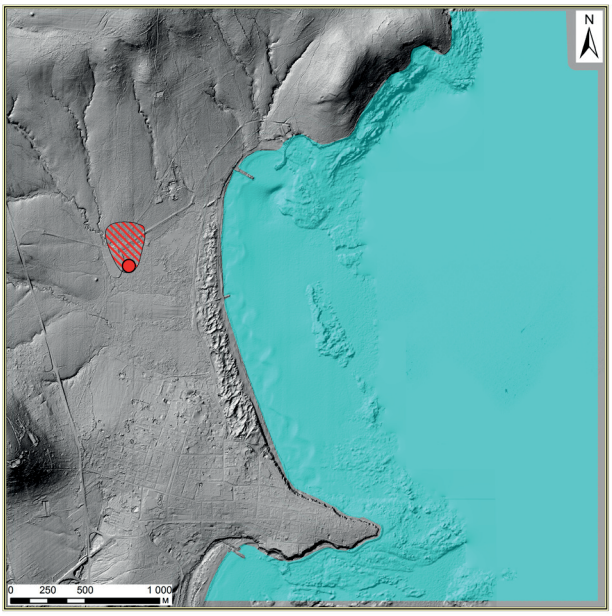


Fig. 35.2. Possible location of prehistoric site near the water well 'Kachkata', bathymetric and land Lidar DTM model, project of the Centre of Underwater Archaeology 2009.



Fig. 35.3. Possible location of prehistoric site near the water well 'Kachkata', topographic map 1:5,000.

decoration. A boat-shaped millstone, bones and bone tools also belong to the group of prehistoric artefacts found in 1989. The research reaching the prehistoric layer covers a very small area; nevertheless, it provides data enough to assume that an EBA settlement existed there. Initially it was located on the mainland next to the ancient river bed.

On the grounds of the scarce data available, we can say so far that the prehistoric pottery from Ropotamo finds its closest parallels in the pottery from Kiten.

7. Stomopolo/Primorsko

In 1922, during the cleaning of a water well in the northern area of the Stomopolo lagoon near Primorsko, Burgas region, at a depth of 9m the workers found prehistoric archaeological artefacts (*fig. 35.1–35.3*). The objects were collected by the local teacher S. Dragulev and handed over to the Museum in Varna (*fig. 36*) (Миков 1925, 236; 1933, 110; Канев 1959, 26, 28 f.; Славчев 2008, 43–56). V. Mikov describes them as 'cone-like clay vessels, others shaped as bowls, a stone hammer, a stone chisel, objects of bone, etc.' (Миков 1925, 236). The geomorphologist D. Kanev mentions also about 'a few stone chisels' and only one 'black clay vessel without special patterns' (Канев 1959, 28). Initially, V. Mikov dated the pottery to the Neolithic and later relate them to the Bronze Age (Миков 1925, 236; 1933, 107). Based on the study of two vessels[10] from

10 M. Lazarov mentions only one vessel.

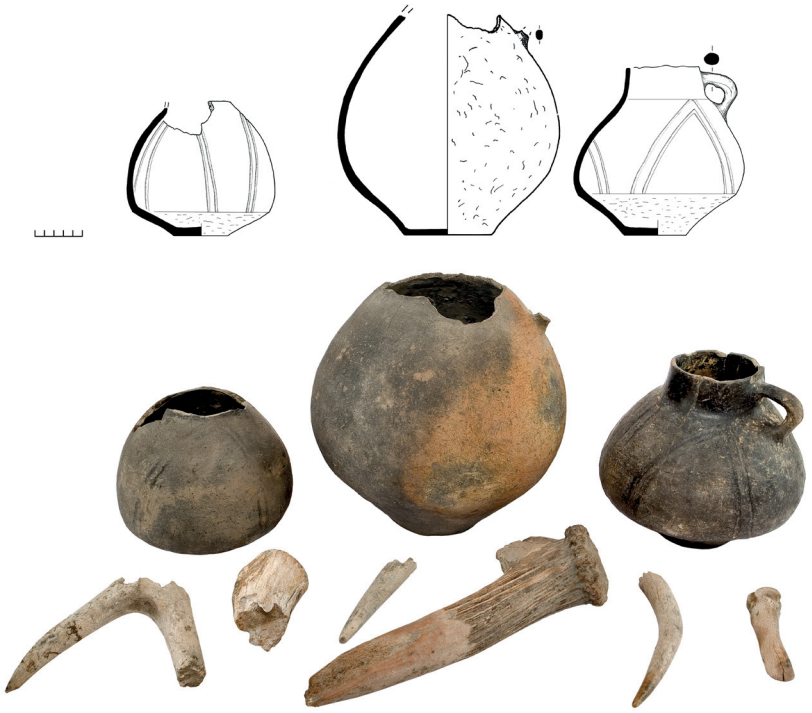


Fig. 36. Prehistoric finds from 1922 from the water well 'Kachkata' in Stomopolo Lagoon near Primorsko, Varna Archaeological Museum (drawing by V. Slavchev).

the depot of the Varna Museum M. Lazarov also is dating the finds to the EBA (Лазаров 1975, 32, 129 and a photo of a vessel without a number on the final page of the second photo sheet). According to V. Slavchev who how republished the prehistoric finds from Stomopolo the artefacts belong to the Neolithic and are related to the Toptepe culture, synchronous with Late Karanovo IV (Славчев 2008, 52). P. Leshtakov and M. Klasnakov support this opinion (Leshtakov 2011, 132).

Digging the well, at a depth of 9m, the workers reached the bedrock to find the spring. This was the depth they found the prehistoric artefacts, in a muddy sediment environment. According to the information given by the local teacher who collected the objects during the work, some later pottery was found too in the upper deposits, indicating a long use of the spring (Канев 1959, 26, 28 f.).

Due to lack of archaeological research and geological and archaeological observations during the digging, the nature of the site has not been specified. According to some of the opinions it was a prehistoric settlement (Лазаров 1975, 129). P. Leshtakov does not rule out this hypothesis, but proposes still another explanation for the great depth the artefacts have been collected at: they fell into an ancient well known even in the Neolithic. According to him, the settlement should be sought in the area of the well but at a higher level, a former terrace located close to the contemporary sea level (Leshtakov 2011, 134).

The scarce information on the geology of Stomopolo is also complemented by a vertical electrical sounding (VES) carried out in 2012 by K. Velkovski and D. Stoev. The interpretation of the collected geo-physical data through VES ascertains that the surface soil layer has a maximum thickness of 1.5m in the western sector of the profile, while to the east, towards the well, it becomes thinner and disappears. A layer containing sand with shells (detritus) lies below; its thickness varies from 2.5m to 4.0m reaching its maximum of 4m in the eastern sector of the profile. Further down a layer of salted sand follows, between 4m and 10m thick, its maximum depth 12m from the surface and in the eastern sector of the profile (toward the well) 8m. Below marl clays follow, from 5m to 15m thick. The surface of this layer has a wavy relief; its maximum depth is 25m and its minimum 3m. Below the marl clays come solid marl going down to more than 30m depth as far as the geo-physical survey reaches. The beginning of this layer of marl clays measured from top to bottom coincides with the information obtained when digging the well that at a depth of ca. 9m the the bedrock was reached (Зидаров et al. 2013, 576 f.). The survey

of the aquatory of the bay in front of the lagoon carried out through LiDAR shows the presence of uplands in the bay with a longitudinal axis north/south (*fig. 35.2*). In some sectors these rocky forms rise up to the water surface, and in some other to 6m to 7m depth. The digital terrain model reveals that they represent an extension of Kondrus Hill to the south and southeast. In the past, at a lower relative sea level and before their partial abrasion, these rock reefs protected the region of the today's lagoon against the direct eastern and north-eastern winds. Probably such was the situation to the transgression at the end of the Copper Age. After the relative sea level rose they ceased to perform this function. The potency of the winds and waves in the bay already opened resulted in the formation of a sandbar and the transformation of the area into a lagoon.

8. Kiten (Urdoviza)

The settlement from the EBA is located in the southern bay of the town of Kiten, south-east of Urdoviza Cape as today a part of it lies below the breakwater of the Kiten yacht harbour (*fig. 37.1–37.4*).

Artefacts from the Bronze Age had been found in the Kiten Bay during underwater archaeological surveys preceding the discovery of the settlement (Лазаров 1975, photo of a vessel missing a number, on the last page of the second photo sheet). The settlement was identified in 1986 during the excavations of a trade ship from the Ottoman Age under the direction of M. Lazarov, K. Porozhanov and V. Popov (Лазаров et al. 1987, 286 f.). Then parts of the wooden constructions of the houses were revealed as well as pottery fragments from the EBA, other artefacts and animal bones.

In 1986 a trench over an area of 10/10m (four quadrants 5/5 m) was excavated at a depth of sea floor 8m. Archaeologists reached maximum depth of 10m over an area of ca. 25m^2 (*fig. 37.4*),[11] where archaeological materials appeared only from 8m to 10m (Лазаров et al. 1987, 286 f.; Порожанов 2004, 311). A large number of vertical posts were found as well as few horizontal beams. The post's upper parts come to different levels: from the bottom surface to 1m depth into the ground. Some of the posts are worked at the top (traces of assembling) suggesting this was their full length. The posts are stuck between 0.2m to more than 1.2m into the seabed. Their thickness is from 0.1m to 0.4m. The horizontal beams are found at a depth of ca. 1m in the ground. A large number of pottery fragments and of animal bones was found mainly in the surface bottom layer (0.1m – 0.4m) (Porozhanov 1991, 109 f.; Порожанов 2004, 312 f.).

The archaeological excavation in 1987 was located ca. 40m to 60m west/north-west of the first one and falls on the track of today's pier and breakwater (Порожанов 2004, 315 f.). Its dimensions were ca. 425m^2 with a main trench of about 300m^2. The depth reached was 5m to 6m below the sea surface. Archaeological artefacts were found from the bottom surface up to 2m depth. About 230 posts with a diameter from 0.1m to 0.4m each were discovered. They are standing vertically as well as at different angles. The length of the posts in depth has not been determined. Their visible parts are one, two or more metres in length. Eleven horizontal beams were also found. According to K. Porozhanov, it seems possible to reconstruct two-storey buildings. Quadrant C 3 contained a heap of five pairs of aurochs horns deliberately cut and arranged close to each other (*fig. 48*), 20 skulls of horses (15 whole and five fragmented), one skull of an extremely large wolf, and bones of a dolphin and belted bonito. This sector is also distinguished by the most numerous wooden posts found there. In the neighbouring quadrants were found: a ceramic female figurine, a bone amulet, a stone cult axe, a ceramic model of a boat, bone *psalia* of a horse bridle, two stylised ceramic female figurines, an amulet or idol, two stone moulds for casting axes, a copper knife (arsenic bronze?) etc. This concentration of peculiar artefacts led the investigators of the site to suggest they might had discovered a cult building. A supporting argument for this is also the circumstance that this is the site's highest part (Порожанов 2004, 315 f.; Porozhanov 1998, 17).

The third trench explored in 1988 was located north of the one from 1987. Its area is 125m^2

11 In a publication from 2004 K. Porozhanov mentions that the excavated area is 50m^2 (Порожанов 2004, 311).



Fig. 37.1. Location of the Early Bronze Age site in the Southern bay of Kiten, southeast of Urdoviza Cape, topographic map 1:50,000.



Fig. 37.2. Location of the Early Bronze Age site Kiten – Urdoviza, orthophoto image from 1918: before the construction of the yacht harbour and the shore infrastructure.

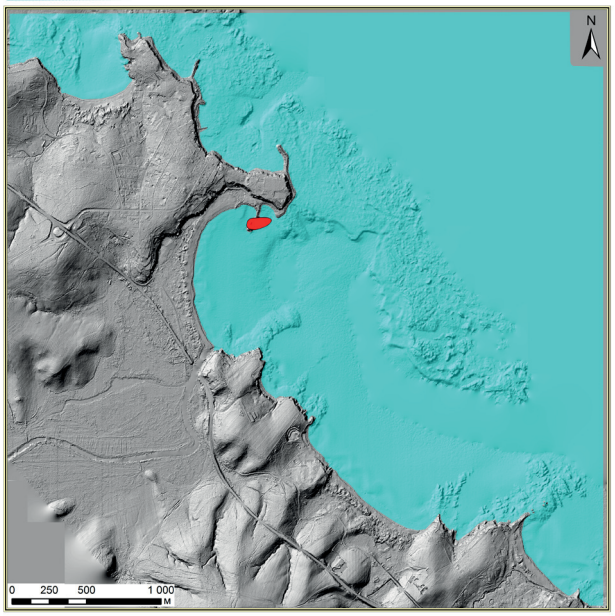


Fig. 37.3. Location of the Early Bronze Age site Kiten – Urdoviza, bathymetric and land Lidar DTM model, project of the Centre of Underwater Archaeology 2009. Note the environment of the site: on the left bank of a lagoon or estuary of the paleo-Karaagach river well protected from northeast by the paleo-Urdoviza cape.

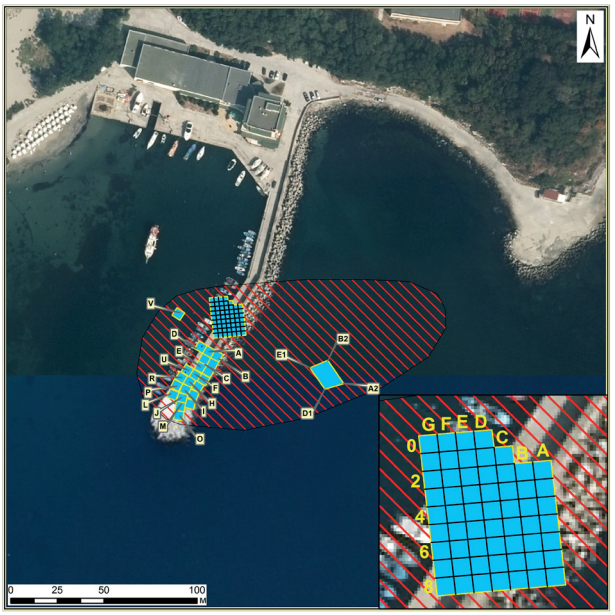


Fig. 37.4. Archaeological trenches of the rescue excavations at the Early Bronze Age site Kiten – Urdoviza, orthophoto image from 2016.

and the work concentrated mainly on 100m^2. The results are 50 wooden posts revealed, five axes or hammers made of antler, two halves of stone moulds for casting metal axes, a large amount of pottery fragments as well as 20 whole vessels, a stylised ceramic female figurine and animal bones (Лазаров et al. 1989, 174; Порожанов 2004, 317; Porozhanov 1991, 111).

During the initial two seasons the researchers determined that the settlement had been constructed over a terrain with a slight slope as the investigated layers were lying between 5m and

6m, and 9m and 10m respectively, below sea level. The bottom surface layer is composed of sand and large stones, between 0.1m and 0.4m thick. The next layer below is composed of gravel mixed with a bit of sand and large stones, reaching from 0.4/0.5m to 1.3/1.4m depth in the ground. Further below there is a layer of compact clay going down to a depth of 2m then a layer of sterile thick clay follows.

Cultural remains have been found in the three upper layers, the greatest concentration in the middle one. The tops of the vertical wooden posts appear in all three layers. According to the researchers, we can distinguish at least three building horizons or phases in the development of the settlement recognised by the vertical position of the posts (Порожанов 2004, 311 f., 315).

In 1989 the research continued during intensive rescue excavations prior to the construction of a pier wall for the Kiten yacht harbour. They were conducted by a different archaeological team.[12] The work continued for eight months and the explored area was 550m^2. Thus, the area investigated in Kiten (Urdoviza) is 925m^2 in total. To specify the stratigraphy of the settlement, the team opened eight ditches some of them reaching to 2.9m in depth in the sea bottom. Five stratigraphic layers have been registered. The surface one is about 0.1m thick, composed of organic material and fine sand. Then a 0.2m thick layer of fine sand and small sea stones follows. Layer 3 consists of large slabs about 0.1m thick, covering a mixed cultural layer from the EBA 0.45m thick and containing shells, black sand, clay and large stones. The size of the stones decreases in depth. Layer 4, 0.2m thick, is composed of fine greenish clay with organic inclusions. The deepest layer 5 consists of hard clay with organics, varying in quantity in depth.

The archaeological remains have been discovered in the initial four layers. They are divided into two cultural horizons. The upper one termed as Urdoviza 2 contains artefacts from the EBA, antiquity and the Middle Ages; it was accumulated during the time of the existence of the Kiten Bay and its employment as harbour and storm shelter. The lower part of this layer contains artefacts from the upper levels of the EBA settlement (the upper sectors of the wooden posts from the buildings) as well as marine sediments covering the settlement. This cultural horizon falls into the stratigraphic layers 1, 2 and 3.

The other cultural horizon: Urdoviza 1, belongs to the settlement from the EBA and is discovered mainly in the stratigraphic layers 4 and 5. Its thickness is 0.75m located between 6.6m and 7.35m below today's sea level. The upper sector of Urdoviza 1 horizon, ca. 0.1m thick, is composed of large flat boulders and sand covering the remains of the EBA settlement. Below the stone cover, the EBA layer is 0.45m thick and reaches 7.15m in depth. The lower sector of the cultural layer contains a stratum of fine and very compact thick clay with small shells, stones and great amounts of organic material. The pottery found in Urdoviza 1 layer belongs to the Bronze Age settlement alone. The lowermost, stratigraphic layer 6 is sterile[13] (Angelova/Draganov 2003, 12–14; Porozhanov 1991, 109; Draganov 1995, 228).

During the rescue excavations in 1989 and 1990 the team explored remains of wooden constructions of buildings: vertical supporting posts and beams of horizontal platforms. The vertical beams are 0.1m to 0.5m in diameter, the majority between 0.25m and 0.3m. The posts are strongly tapered and have been fixed into the ground as their height from the lower end to the horizontal platforms representing the base of the buildings is between 1.2m to 2.4m. The horizontal beams constructing the floor platforms are rectangular in section. They have been fastened to the vertical ones by means of assemblies and ropes discovered at a couple of spots in situ. These angular links lie in the fourth stratigraphic level. The

12 Kiten (Urdoviza) was explored during 1986 to 1988 under the direction of V. Popov and K. Porozhanov. After 1989 the team of H. Angelova and V. Draganov worked at the site.

13 After completion of the research in Kiten in 1990 and clarifying the situation in Sozopol after the excavations in 1992, a doubt arose that layer 6 might be in fact a stratigraphic hiatus with a Copper Age layer below it. In 2014 an attempt was made to verify this hypothesis; however, due to the great thickness of the deposition accumulated over the EBA settlement after the harbour was constructed, it was not possible to reach the desired depth. The question of a presence of Chalcolithic layer in Kiten remains still open (Ангелова et al. 2015, 128–132).

surviving height of the vertical posts above the horizontal platforms is between 0.3m and 0.4m. This is also the thickness of the layer covering the ruins from the EBA which probably has preserved the wooden posts while higher constructions are eroded. This idea is supported by the fact that in Kiten an unusually large number of whole ceramic vessels has been discovered. The reason for this is that the cultural layer of the EBA settlement was covered with sediments soon after the terrain was flooded thus protecting the remains. The many vertical posts fixed at different height and missing a clear connection with the construction of the buildings are a consequence of reconstructions and several following building stages (Draganov 1995, 228 f.).

The analysis of the stratigraphic and taphonomic observations leads to the conclusion that the settlement was located on the mainland close to the ancient bed of the Karaagach river, a few hundred meters from the seashore as the ancient sea level was at least ca. 8.5m lower than the contemporary one. The ancient riverbed was discovered during the archaeological research in 1989. It was identified by the lack of artefacts, ascertainment of a steep slope and the presence of a layer of sand. The settlement developed on the left river terrace displaying a slight inclination in N/NE–S/SW direction and covering an area 40m to 60m wide. The platforms serving as foundations of the buildings were rising about 1m above the ancient terrain (Draganov 1995, 229; Angelova/Draganov 2003, 12–14; Georgiev et al. 1994, 322–325). The excavations revealed only the southern border of the settlement which was close to the ancient bed of the Karaagach river; the other borders remain beyond the explored sectors (Draganov 1995, 228).

The pottery coming from the site has been dated to the EBA in general by all of the researchers (Лазаров et al. 1987, 286 f.; 1988, 39 f.; 1989, 174; 1991, 36–39). The pottery from Kiten has been studied by K. Leshtakov and V. Draganov in detail (Драганов 1990, 172; Leshtakov 1994, 24–38). The percentage of whole vessels is unusually high especially compared to the terrestrial sites from the same age. The majority of vessels are handmade, maybe few of them were produced on a slow turning wheel. They are of local production and imports have not been recognised. The fracture



Fig. 38. Early Bronze Age fine ceramics from the settlement Kiten – Urdoviza.



Fig. 39. Early Bronze Age ceramics from the settlement Kiten – Urdoviza.



Fig. 40. Early Bronze Age ceramics from the settlement Kiten – Urdoviza.

is fine containing coarse sand and broken shells. The vessels have been irregularly baked and bear stains. The colour is grey, greyish brown, brown and light brown. The surface is smooth although burnishing is rare (*fig. 38–40*).

The shapes of the Kiten pottery are not too manifold: bowls, deep bowls, pots and storage jars, jugs, dishes, amphora-like and askos-like vessels and kettles (*fig. 41–45*). The decoration is the most sensitive chronological element of the pottery complex from Kiten. The vessels bear pressed bands, buds, dents, patterns stamped with a tool (pierced or stamped decoration), cord decoration as well as compositions of all these kinds (*fig. 43*).

The pressed bands and the finger impressions are the most common decoration. Often, they are

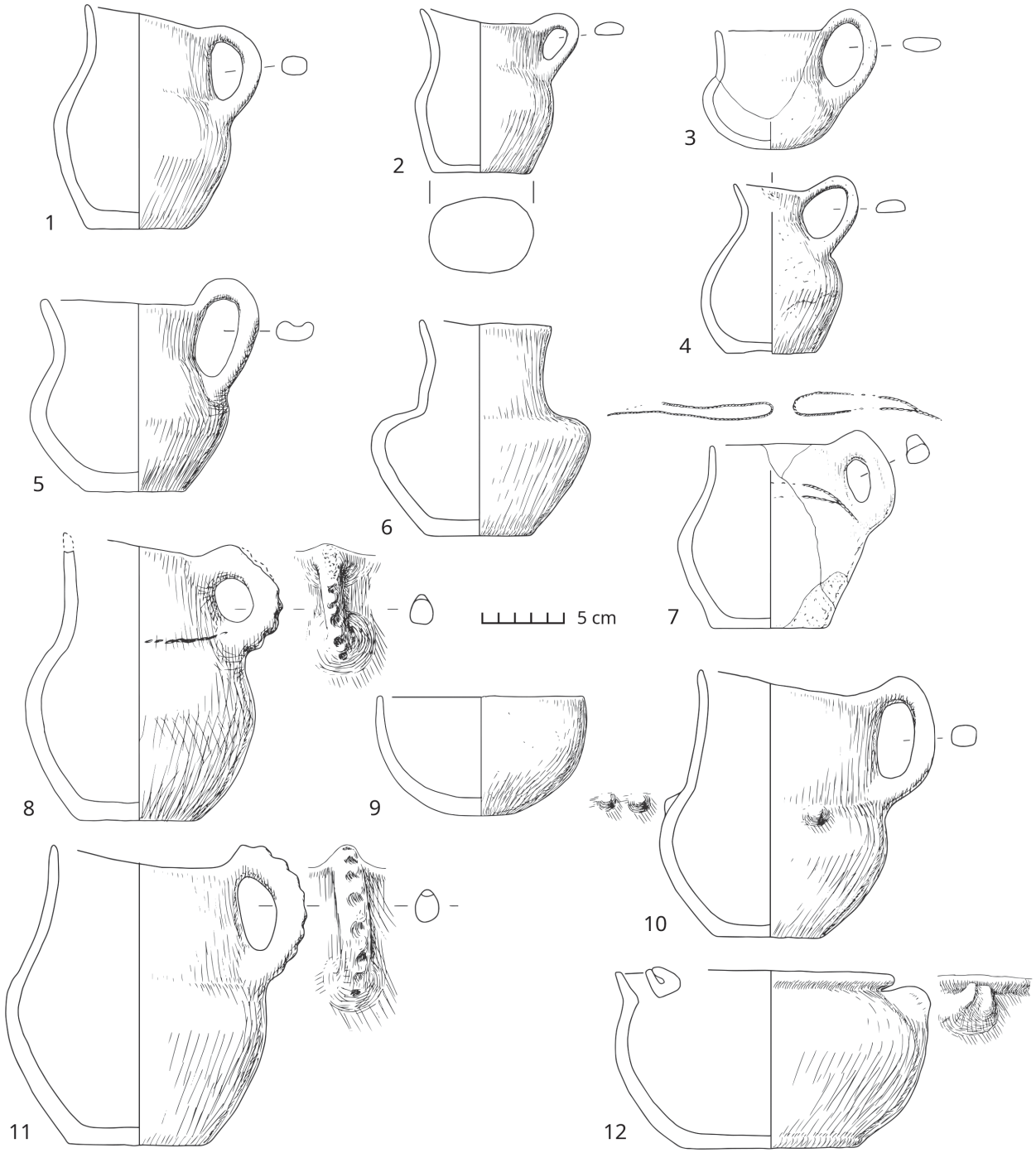


Fig. 41. Early Bronze Age ceramics from the settlement Kiten – Urdoviza (drawings by H. Vasileva).

applied to the mouth, shoulders and the neck of jugs, pots and some types of bowls. Finger impressions applied to the vessels mouths as the only decoration also appear often. Comparatively rare is the decoration of buds alone or together with incised and stamped patterns. There are also vessels, mainly jugs and bowls, without any decoration. Vertical flat handles rising above the mouth and decorated with finger and nail impressions along the outer edges are a feature of Kiten pottery. Some wide bowls with straight mouth rim bear horizontal handles. Pseudo-tunnel handles on the mouth of middle-size bowls appear comparatively seldom. The 'ladles' with triple handles are a peculiar feature of the Kiten complex, similar pieces are also known from the submerged settlement of



Fig. 42. Early Bronze Age ceramics from the settlement Kiten – Urdoviza (drawings by H. Vasileva).

Ezerovo II in the Varna region (*fig. 38*). The function of this type of specific vessels is unclear but their use as vessel for keeping and transport of fire or burning charcoal seems most likely.

The cord decoration is widely spread appearing in various patterns. One of the fragments displays pseudo-cord decoration of caterpillar type testifying to an earlier phase in the development of this technique. Usually the cord decoration is running below the rim of the vessel which is characteristic of the classical stages in the development of the cord-marked pottery. The cord decoration is often combined with other decorative techniques such as buds and impressions.



Fig. 43. Early Bronze Age ceramics from the settlement Kiten – Urdoviza with decoration (1, 2), 3 – decorated EBA ceramic fragment from the settlement in the harbour of Sozopol.



Fig. 44. Early Bronze Age finds from the settlement Kiten – Urdoviza.



Fig. 45. Early Bronze Age ceramics from the settlement Kiten – Urdoviza.

Judging from the pottery, the settlement is related to the second and third phase of the EBA (Ezero A2–B2 – levels IX–III/II, Mihalich, St. Kirilovo). Some fragments find parallels also with the early levels of Ezero (levels XIII–X). However, especially close are the parallels with the pottery complex of Ezerovo II (Cernavodă II) in the north. The connections with St. Kirilovo and Mihalich in south-east Bulgaria are less pronounced (Leshtakov 1994, 24–38).

The absolute date of the site has been determined by dendrochronological and ^{14}C analyses accomplished in several different laboratories. The laboratory in Berlin has dated eight ^{14}C samples from Urdoviza to 4180 BP and 4040 BP calibrated between 2850 calBC and 2600 calBC (Görsdorf/Bojadziev 1996, 157 f.). The date specified in the laboratory in Heidelberg is similar: between 4210 BP and 41150 BP (see *table 3*).

The settlement has been dated also by 85 dendrochronological samples from posts. Based on this a 285 years long dendro-scale has been elaborated which is among the longest so far established for the EBA on the Balkans. Four (or five) phases of settlement life have been determined with indications of interim repairs of buildings. There were periods of weak construction activities of 10 to 20 years between the phases. Through nine ^{14}C samples, the phases of development of the settlement have been related to the absolute time scale (Kuniholm et al. 1998, 402).[14]

According to the dates and cultural characteristics, the settlement in Kiten fits to the beginning of the second phase of the EBA along the western Black Sea coast (the early phases of Cernavodă – Ezerovo/Ezero VI–IX cultures = 2900–2700 BC). The artefacts from the settlement find their closest parallels with the archaeological material from Cernavodă II, the submerged settlement of Ezerovo II, Ezero VIII–V, Yunatsite XIII–IX, late Troy I and Troy II (Leshtakov 1994, 26–28; Angelova/Draganov 2003, 16) (*table 4*).

14 ^{14}C dating of the settlement has been specified on wood sections of 15 years each in Heidelberg Laboratory:

Lab-code	^{14}C date	Relative years Kiten
Hd15460	4204±27 BP	951–965
Hd15964	4122±23 BP	1026–1040
Hd15209	4216±20 BP	966–980
Hd15567	4246±19 BP	1041–1055
Hd15139	4157±15 BP	981–995
Hd15208	4206±15 BP	1056–1070
Hd15879	4132±17 BP	996–1010
Hd15458	4236±27 BP	1086–1100
Hd15987	4094±16 BP	1011—1025

Lab-code	Context	Type of sample	^{14}C date	
Bln-4113	1,80 m in layer III, quadrant A3, depth in seabed 2.50m	Charcoal from wood	4850±60 BP	3710–3620 calBC 3580–3530 calBC
Bln-4111	Layer III, quadrant A, depth in seabed 0.40-0.70m	Wood, post №6	4170±50 BP	2880–2850 calBC 2820–2660 calBC 2640–2620 calBC
Bln-4112	Layer III, quadrant A, depth in seabed 0.40-0.70m	Woods, post №3	4050±60 BP	2620–2470 calBC
Bln-4114	Layer III, quadrant A, depth in seabed 0.40-0.70m	Wood, post №13	3980±60 BP	2280–2400 calBC 2380–2360 calBC
Bln-4115	Layer III, quadrant A3, depth in seabed 2.30m	Burned wooden post, length 2,30 m	4040±50 BP	2610–2470 calBC
Bln-4117	Layer III, quadrant B, depth in seabed 0,40-0.70m	Burned wooden post №24	4060±50 BP	2850–2820 calBC 2660–2640 calBC 2620–2490 calBC
Bln-4118	Layer III, quadrant B, depth in seabed 0,40-0.70m	Burned wooden post №64	4070±60 BP	2860–2810 calBC 2670–2490 calBC
Bln-4119	Layer III, quadrant B, depth in seabed 0,40-0.70m	Burned wooden post №16	4160±50 BP	2880–2850 calBC 2780–2620 calBC

Table 3. ^{14}C dates for Kiten – Urdoviza from the Laboratory in Berlin (after Görsdorf, Bojadziev 1996, 157 f.).

Phase	Relative years Kiten	Absolute date
Phase Kiten 1	1073	2778±10 calBC
Phase Kiten 2	1080	2771±10 calBC
Phase Kiten 3	1100	2751±10 calBC
Phase Kiten 4	1114	2737±10 calBC
Phase Kiten 5	1136	2715±10 calBC

Table 4. ^{14}C Dating of Radiocarbon samples from Kiten.

Artefacts from Kiten Associated with Metallurgical Activities

During the archaeological research in 1987 in the area of the so called 'temple' a copper (bronze) axe and two different halves of stone moulds for casting axes were discovered (*fig. 46*). Later on, two more casting moulds, a knife and a ceramic *tuyère* were also found. Unfortunately, the moulds and the metal artefacts are lost and we do not have any more detailed information about them. Beyond any doubt, the casting moulds testify to practicing metallurgical (casting) activities by the inhabitants of the EBA settlement. Both nozzles certainly were also part of the inventory of the ancient metallurgist as they bear clear traces of strong heating and small oxidised copper particles at the top (*fig. 47*).

The osteological material from the settlement at Urdoviza cape has not been explored totally. However, from the study of part of the collection it can be concluded that the settlement was located close to lake or swamp basins with periodic river floods and extensive forest biotopes (Боев/Рибаров 1990, 53–57). The analysis of the bone material shows that hunting was an important part of the livelihood while stock breeding was not widely practiced. Out of all mammalian bones found in 1987 and 1988, 43.11% belong to domestic animals and 56.89% to wildlife (Ribarov 1991, 113–117). The domestic animals are represented by two kinds of cattle, one of them with clear features of a domestic animal, while the features of the other one suggest a running process of domestication. Also pigs, sheep, goats and horses are present.

A large amount of horse's bones has been registered and two kinds of them may be distinguished: big broad-hoof horses (*E. latipes*) and smaller steppe ones (*Tarpan*). N. Spassov and N. Iliev who have studied a part of the bone material from the settlement question G. Ribarov's



Fig. 46. Heavily corroded copper axe from the Early Bronze Age settlement Kiten – Urdoviza.



Fig. 47. Early Bronze Age ceramic tuyere from the settlement Kiten – Urdoviza.



Fig. 48. Very large corns from Aurochs (*Bos taurus*) from the Early Bronze Age settlement Kiten – Urdovitsa: probably a 'capital trophy' deposited in the 'sanctuary'.

conclusion on the domesticated horse (Ribarov 1991, 113–117; Spassov/Iliev 1997, 297). There is a significant predominance in number of bones of bovines and horses compared to bones of pigs, goats and sheep which clearly reflects the nature of economy of the people and the surrounding environment. Bones of species that live in the open sea (dolphin, tuna fish, etc.) have been found, which implies fishing.

Agriculture was poorly developed. Alongside the results of pollen analyses, the small number of agricultural tools as forked rods and diggers testify to the same (Лазаров et al. 1988, 39).

Conclusion

The submerged settlements on the western coast of the Black Sea mainly belong to two chronological periods: the LCA and the EBA. The ones from the Late Copper Age display two phases. The earlier settlements (the ones in the Varna lakes) belong to the Varna culture, and the other ones to a period later than the final stage of the Gumelniţa/Kodzhadermen/Karanovo VI culture. The sites from the Bronze age more numerous than those of the Late Copper Age. It should also be noted that most of the settlements belong to the second phase of the Bronze Age and are synchronous with Ezero VIII–VII cultures. The region of the Medni Rid seashore displays a cultural continuity of about 2000 years between the Late Neolithic (the settlements on the

mainland) and the end of the Chalcolithic (settlements on the mainland and submerged ones). The settlements from the Late Chalcolithic we found submerged, today are the latest phenomenon in this continuum. The submerged chalcolithic settlements of the Medni Rid seashore along with other peripheral settlements in the Rhodope mountains survive the crisis in the late 5th mill. BC, all of them continuing into the first centuries of the next millennium (Аврамова 1992, 240–247; Делев et al. 2015, 188–191).

The above representation of the submerged settlements shows that the ones from the LCA and EBA can be defined as coastal settlements in the narrow sense of the word. They were deliberately founded in proximity to the sea. The location of the settlements from the Neolithic known along the southern Bulgarian seashore demonstrates differences from that of ones from the LCA and EBA: the latter following a different geographical logic of establishment and life. Neolithic settlements have been registered next to the contemporary coast line, some of them just a few metres away, as well as on high terraces above the sea. Most likely during the Neolithic the sea level was lower and known up to now settlements along the seashore were significantly more remote from the coastal line in the past thus not being 'coastal sites'. It is logical to assume the existence of Neolithic settlements on their contemporary coastline but such have not been discovered yet. We can expect such sites underwater at a depth greater than the one of the settlements from the LCA and EBA.

The settlements from the LCA were abandoned for reasons that remain unclear; nevertheless, we can note a correlation with a change in the sea level and the ancient ecological environment. Along the northern and south-western Black Sea coast settlements appeared again during the EBA in the same or similar places. At the spot where settlements from both ages overlap, a stratigraphic hiatus has been registered and its nature suggests that it has been formed within water environment. At the end of the EBA the settlements were abandoned once again for unclear reasons.

The pottery found in Sozopol and Atia has a clear connection with the Chalcolithic tradition although it belongs to a later phase in its development and shows many new 'post-chalcolithic' elements in technology, vessel shape and decoration pattern. This means that the settlements continued to exist after the classical phases of the Gumelniţa/Kodzhadermen/Karanovo VI culture and continued their development also during the first half of the so called 'transitional period'. On the other hand, the presence of artefacts from the settlement at bay in front of the Ropotamo river estuary, characteristic of the intermediate stages of the Cernavodă III culture as well as the earlier artefacts from Kiten, show that the renewal of the settlements along the southern Black Sea coast began at least as early as that of the inland settlements. The comparative analysis of the particular submerged settlements from the LCA as well as of those from the EBA reveals that they emerged and disappeared at different moments and experienced a different length of habitation.

Although belonging to different cultures and historical periods, the settlements from the LCA and EBA often appear at similar or even the same places, sometimes in the immediate vicinity, sometimes in a superposition. A. Margos and I. Ivanov were the first to pay attention to this phenomenon (Иванов 1981, 289; Margos 1973, 279). Probably the reason is that during both periods there were similar topographic conditions and the locations of the earlier settlements again appeared to be most suitable. Although the submerged settlements were located at various places along the seashore, each of them with its specifics, between them one can observe topographical similarities giving grounds to suggest that the leading motives in choosing a place for settlement were exactly the topographic factors: proximity to the sea, proximity to a river or a *liman*, protection against winds, southern exposure and a slight slope of the terrain (Prahov 2013, 120–122). A special attention should be paid to the proximity of the LCA and EBA sites from the southern Bulgarian Black Sea coast to the copper sources of the Bourgas area.

We don't yet have a single answer to the question of what was the distance of the settlements from the shoreline. The fact that all submerged settlements are at a similar level shows that their location is related to the ancient sea level. The

comparison of the settlement levels reveals minor differences between the sites in the Varna lakes and the ones along the Medni Rid seashore.

The main question concerning the topography of the coastal settlements is what the nature of the water basin they developed along was: the sea, a freshwater or brackish *liman* or a river. According to the initial thesis of the explorers and investigators of the submerged settlements near Varna they were located along the coast of a sea bay (Шкорпил/Шкорпил 1921, 79 f.; Mapгос 1961a, 1 f.; 1961b, 128 f.; 1965, 57–60; 1973, 268 f.; Mapгос/Тончева 1962, 14). However, the interdisciplinary studies associate the settlements almost everywhere with freshwater or brackish basins although located close to a sea environment.

The recently accumulated data on the development of the prehistoric metallurgy in the region of Medni Rid during the Chalcolithic and the EBA lead to the hypothesis of a connection between the settlements along the seashore during these epochs and the rich deposits of copper and gold existing nearby. The archaeometric analyses of copper artefacts from the famous Varna 'gold necropolis' and the necropolis near Durankulak clearly show the importance of the mineral deposits in the region of the Burgas, Medni Rid and Strandzha mountains for the supply of copper to the Chalcolithic population north of the Balkan mountains (Pernicka et al. 1997, 106–118; Димитров 2007, 59–63, Карта 1–2). The findings of crucibles, casting moulds, metallurgical bellows, copper axes, knives and daggers found in Sozopol and Kiten come as an additional argument for this hypothesis. If we compare the explored area of these settlements with the area of the numerous sites on the mainland from the same periods we will notice the wealth of artefacts associated with metallurgy within the submerged settlements. The review of the general topography of the western coast of the Black Sea suggests that one of the easiest, most convenient and safest corridors for raw material exchange from the Strandzha seashore to the north is via the sea.

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Apollonia Pontica and the South-Western Black Sea Coast in the Thracian and Antique Periods (Late 2nd Millennium BC to Early 1st Millennium AD)

Keywords: Apollonia Pontica, Bulgarian Black Sea coast, Greek colonisation, colonial chora, Greek-Thracian relations

In the late 7th cent. BC, settlers from the Ionian city of Miletos founded Apollonia at the south-eastern end of present-day Burgas Bay. The city became the main factor in the region's development during the following centuries, at least until the arrival of the Romans. However, Milesian colonists did not arrive in an empty country.

Late Bronze and Early Iron Age

The evidence from the southern Black Sea coast from the Late Bronze Age (LBA) is very meagre without a single properly investigated site, but the period deserves attention because of a few stray finds of particular significance. Among them, most important are copper ingots found in the region: an ox-hide shaped ingot from the village of Cherkovo to the west of Burgas, and a cargo (?) of bun-shaped ingots from the sea at Maslen Nos. The entire set of problems of the ingots' distribution in Thracian lands has been commented upon (see Leshtakov 2007; Paschalidis 2007, 437 f.; Doncheva 2012). The finds from the coastal area are not isolated, with other specimens found not that far in the interior, along the river Tundzha in Elhovo Municipality (and more in present-day northern Bulgaria). The latter seems to suggest both land and river transportation, but the hoard from Maslen Nos implies maritime trade and therefore the existence of coastal settlements.

The question remains open whether the ingots were imports from the Mediterranean, or rather were exported from the region under discussion that was rich in metals (Leshtakov 2007, 453 f.). Stray finds from the region of Burgas, including hollow celt axes, a mould for casting them and others, indicate the existence of a metallurgical centre in the LBA (see Класнаков 2006).

The so-called 'stone anchors', although enthusiastically dated to the LBA (see Димитров et al. 1982; Димитров 1982, 464–473; Порожанов 1989; Hiller 1991, 209; Paschalidis 2007, 438), should be kept out of the discussion, as none of them has been found in a secure context, their ubiquity does not correspond with other LBA evidence, and such objects remained in use in much later times (Leshtakov 2007, 454). One of the very few specimens that offer any possibility for independent dating is an anchor with two holes that was found in the sea off Sozopol and bears a Greek inscription, most probably Hellenistic (IGBulg. V, 5154).

Due to lack of information, it is difficult to trace the transition to the Early Iron Age (EIA). Coastal Strandzha belongs to the area of the Thracian 'megalithic culture' of the EIA with the typical dolmens, known from the surroundings of future Apollonia, to the north and south of it, on the western side of Medni Rid near the modern villages of Rosen and Ravna Gora and in the area of cape Maslen Nos and Kitka hill near present-day Primorsko (Делев et al. 1982, 345; Делев 1990, 143–149; Gyuzelev 2008, 106, 111, 115). The chronology of these family tombs reaches down to the 6th cent. BC (Делев et al. 1982, 321 f.; Агре/Дичев 2006), which indicates the presence of Thracians in the area by the time the Milesians arrived.

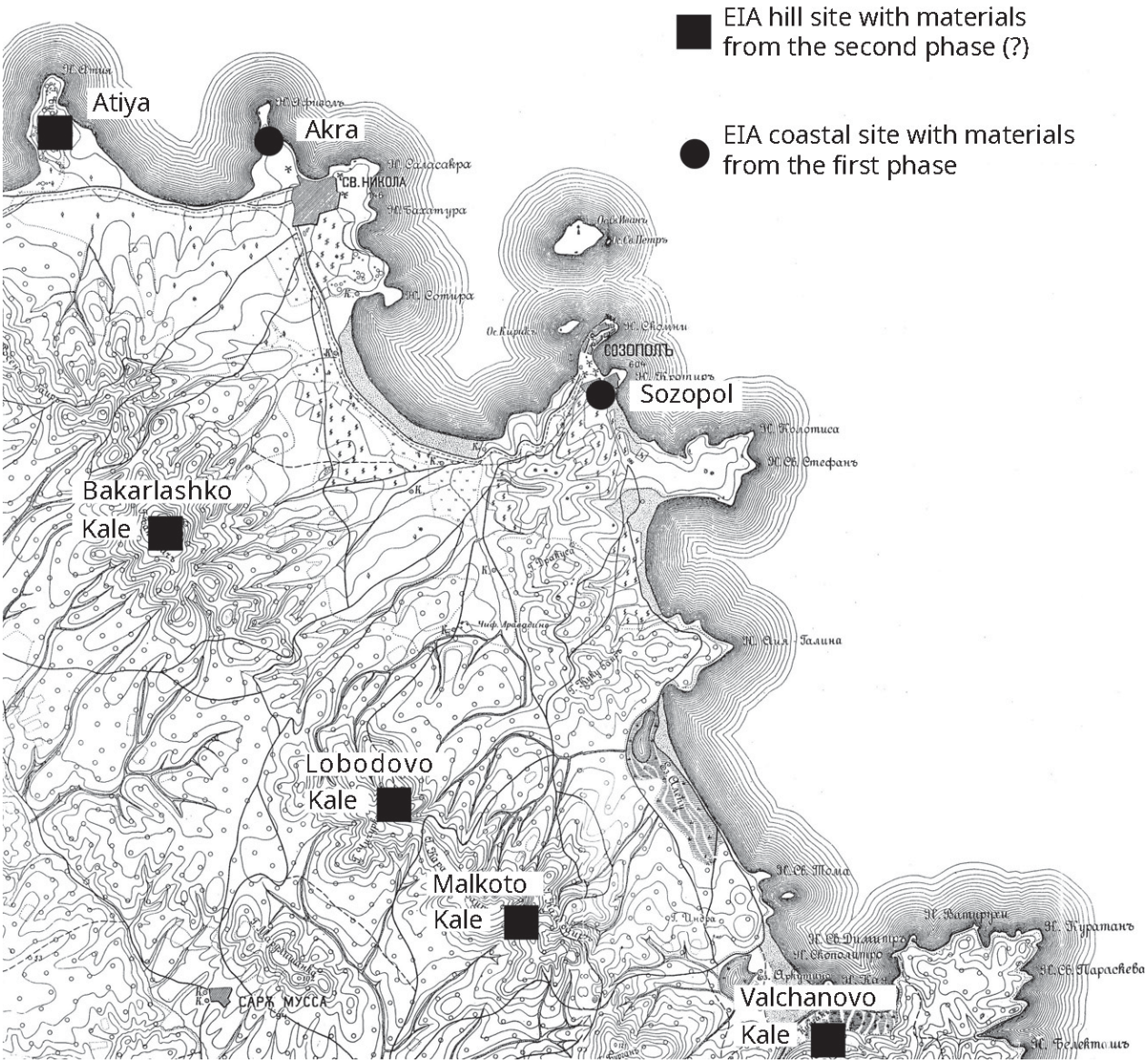

Fig. 1. Early Iron Age settlements in the region of present-day Sozopol.

There is evidence also of settlements: on several of the peaks of Medni Rid that delimits from the west the coastal plain of Apollonia, Thracian 'fortresses' have been detected: Bakarlashko Kale, Lobodovo Kale, Malkoto Kale, and Chengersko (Valchanovo) Kale (Венедиков et al. 1976; Gyuzelev 2008, 107–111) (*fig. 1*). Most probably, the sites relied on natural defences, as the documented remains of fortifications date from later times, as in the case of the 4th cent. BC at Malkoto Kale, which is the only one subjected to archaeological investigations (Венедиков et al. 1976, 131–155; Делев et al. 1982, 360–378). Several levels of habitation were identified and the analysis of the pottery dates the emergence of the settlement to the 9th cent. BC; many of the vases are decorated with a combination of ornamentation techniques: fluted, incised and stamped (Domaradzki et al. 1991; Домарадски et al. 1992). Based on stratigraphic observations and the discovered Greek imports, a continuous habitation is tentatively presumed from before to after the colonisation (Shalganova/Gotsev 1995, 328; Archibald 1998, 34–36), although certain caution is necessary (the earliest certain Greek imports are dated to the 5th cent. BC, Делев et al. 1982, 367, and some are misidentified, see Gyuzelev 2008, 108). Nonetheless, it would appear that Milesians found a settled Thracian population in the



Fig. 2. Early Iron Age pottery from Harmanite neighbourhood of present-day Sozopol.

area. It should be remembered, however, that the so-called Thracian 'fortresses' are located in the hills, at a distance from the shore.

The situation on the coast, where the actual first encounter of Greeks and Thracians took part, remains less clear. Ceramic fragments from the EIA are reported from Sozopol's old town, the site of future Apollonia, but without a pronounced layer and with unspecified chronology (Nedev/Panayotova 2003, 95 f.; Gyuzelev 2008, 119 f.).

Recently, traces from EIA habitation, probably a settlement on the southern slope of a low hill close to the shore, were detected about a kilometre away, in the present-day Harmanite neighbourhood (Панайотова et al. 2014a, 268 f.; 2014b, обр. 2). However, the discovered pottery (*fig. 2–3*) dates from the first phase of the period, which suggests a considerable hiatus before the arrival of the Greeks.[1]

Also, recently remains from the EIA were discovered on cape Akra, the northernmost spur of the peninsula of present-day Chernomorets, several kilometres to the north-east of Sozopol. Initially, the pottery that is similar to that from the Harmanite neighbourhood (mainly with relief, incised, and fluted decoration, almost without stamps) has been dated from the 8th to the 6th cent. BC, probably early within this period (Христов 2013, 24 f.). Two radiocarbon samples, however, provided dates in the 9th cent. BC (Христов 2017b, 15), which fact supports the observations on the materials from Sozopol's new town.

Other sites around Burgas Bay also hint at a possible hiatus between the Thracian occupation of the coast and the arrival of the Greeks. The best-known example is the peninsula of ancient Mesambria that also yielded pottery from the EIA (Venedikov 1980). The suggested continuity between the Thracian settlement and the Dorian colony (last in Preshlenov 2003, 164 f.) was quickly contested (Alexandrescu/Morintz 1982), and the results from new investigations confirm a long interval (Божкова et al. 2008, 306; Божкова 2009, 146; Божкова/Кияшкина 2014, 225).

EIA Thracian pottery has been discovered at Kostadin Cheshma near Debelt in the area of a

1 We are grateful for the consultation of Dr. K. Nikov and Dr. G. Nehrizov from NAIM–BAS.

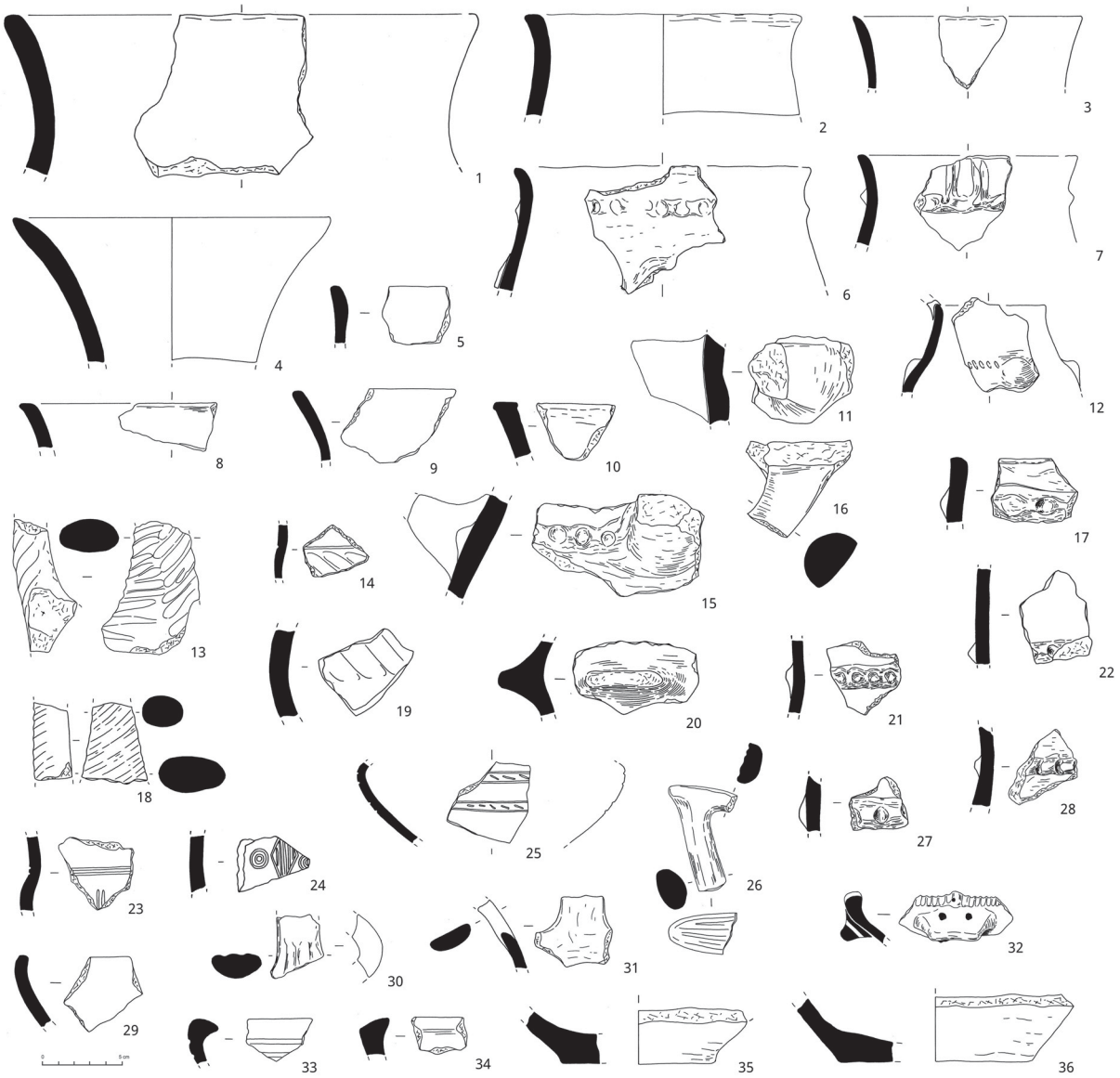

Fig. 3. Early Iron Age pottery from Harmanite neighbourhood of present-day Sozopol.

field of pits with Archaic Greek imports (see below), but not in the pits themselves (Балабанов 1999, 71 f.). Again, no clear contact situation could be registered.

To the south of Sozopol, pottery from the later phase of the EIA, after the 8th cent. BC[2] that is immediately before the arrival of the Milesian colonists, is known from a tumulus near modern Primorsko (Балабанов 2014; Балабанов/Пантов 2015). The context is not clear, as two Hellenistic graves were investigated in the tumulus, and the early materials come from its base.

This rather vague situation is probably due mostly to the state of research and to the sometimes problematic dating of early Thracian pottery. Nonetheless, some accompanying evidence suggests a very early contact between the local Thracians and the Ionian colonists, for example, the presence of Thracian pottery in some of the earliest contexts on the island of St. Kirik. Besides, the chronology of the early imports from Kostadin Cheshma – almost immediately after the foundation of Apollonia – is another indication of the presence of natives in the area.

2 We are grateful for the consultation of Dr. K. Nikov.

Archaic and Classical Period

The foundation of Apollonia in the late 7th cent. BC is the last episode of the first phase of the Ionian colonisation in the Black Sea region (Tsetskhladze 1994, 115–118) that began in the middle of the century with Istros (and Orgame) in Northern Dobrudzha and Boristhenes/is at the entrance of Dnieper-Bug estuary with respective historical dates of 657/656 BC and 646/645 BC (Euseb., Chron. 95b Helm). Some very early finds from the Northern Pontic area seem to corroborate such a chronology (Kerschner 2006; Buiskikh 2016).

The delay of Apollonia's foundation several decades later is somewhat puzzling, as the city provided a much-needed port of call for the ships sailing northwards, especially coming after the notoriously inhospitable Salmidessos (see Isaac 1986, 239 f., n. 167). It is probably not accidental that the anchor was the constant device on the coins of Apollonia. Certainly, the place had other advantages as well, for example, its proximity to the metal deposits of Medni Rid ('Copper Ridge' in Bulgarian) that were actively mined already during the Archaic period. Within the second half of the 7th cent. BC, between the foundations of the first colonies and the foundation of Apollonia, the Ionian settlers should have been able to obtain information about these resources despite the doubts voiced about the role of metals for the Archaic colonisation (Treister 1996, 169 f.; Tsetskhladze 2009, 335). In this respect, the foundation of Apollonia probably resulted not only from the difficult situation of Miletos in this period: for decades, the Ionian polis suffered from the Lydian expansion and lost territories, which probably prompted the city to send away some of its population (Tsetskhladze 1994, 123–126; Greaves 2002, 17). However, the analysis of the Milesian colonisation was able to identify other economic interests as well (Doonan 2006, 53 f.).

The historical date of Apollonia's foundation, provided by Pseudo-Skymnos (729–733), 'fifty years before Cyrus' (ca. 610 BC) (see Бошнаков 2007, 91–110), conforms with the earliest finds: vases of Middle Wild Goat II style (or South Ionian Archaic Ic, see Kerschner/Schlotzhauer 2005, 8, 25–33) (Лазаров 1990, No 1; Недев 2016, 44 f., обр. 1) and North Ionian 'bird bowls' (Недев 2016, 45 f., обр. 2). The new investigations on the island of St. Kirik that started in 2009 increased the quantity of early pottery (*fig. 4–5*) dramatically without visibly changing the chronology.

Pottery confirms the other part of Pseudo-Skymnos' information about the Milesian origin of the colonists partially: among the early materials, along with Milesian fine tableware, there are also numerous South Ionian transport amphorae, indicating close ties with that region. At the same time, the participation of groups from other *poleis* should be expected (Greaves 2002, 109; Tsetskhladze 2009, 335), including from northern Ionia. The Archaic monochrome pottery from the Pontic colonies, including Apollonia, reveals numerous Aeolian shapes (Ников 2012, 121–149) and indicates the participation of Aeolian Greeks as well (Handberg 2013). Later, additional settlers (*epoikoi*) strengthened the demographic potential of the *apoikiai* (Avram 2012, 198–207).

No written sources elucidate the history of Apollonia and the region in the Archaic period. The mention of Anaximander as Apollonia's *oikistes* (leader of the colonists) (Ael., Var. Hist. 3.17) could be circumstantial evidence for the arrival of a new group of colonists in the mid-6th cent. BC (Avram 2012, 201–205). Aristotle (Pol. 5, 3, 1303a) provides explicit information about *epoikoi* in Apollonia, but their connection with Anaximander and the chronology of the events, respectively, are not that obvious (see below). Herodotus (4, 93) mentions the Skyrmiadai, a Thracian people, living 'above Apollonia' in the context of the Scythian campaign of Darius, but pays no attention to the city itself. Archaeology is capable only partially to fill that void.

Ancient Apollonia consisted of two distinct parts: the offshore island of St. Kirik and the peninsula of present-day Sozopol's old town, with a combined area of about 25ha (*fig. 6*). This urban plan is paralleled by the city of Istros in Dobrudzha (see Avram 2003a, 280–282). In this respect, Strabo's information (7, 6, 1) that most of the city including the temple of Apollo was located on an island (St. Kirik) appears not to be true for the Archaic and the Classical periods. Archaeological evidence indicates a more or less synchronous settlement on both the island and the peninsula: at both places, the earliest pottery dates from the late 7th cent. BC

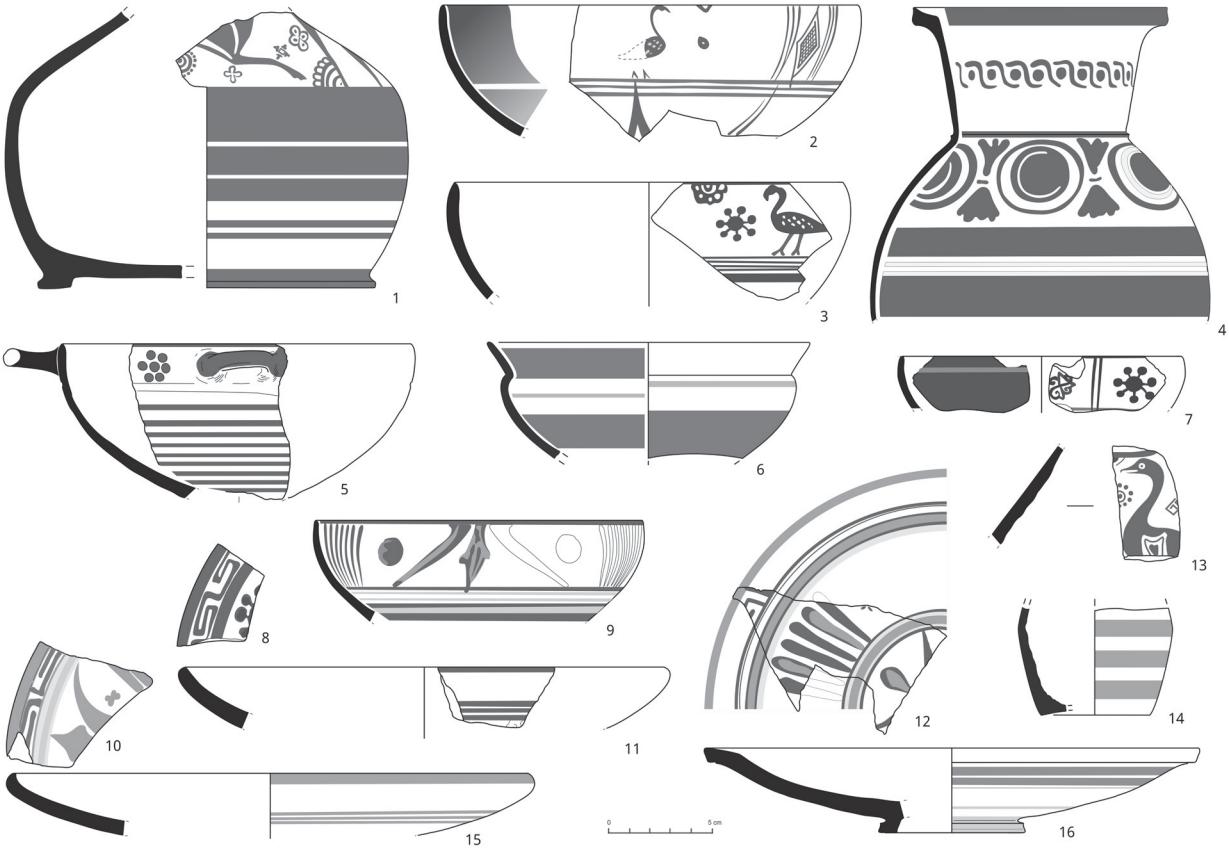

Fig. 4. Archaic East Greek pottery from the island of St. Kirik (late 7th/early 6th cent. BC).



Fig. 5. Archaic East Greek and Attic pottery from the island of St. Kirik (late 7th/6th cent. BC).

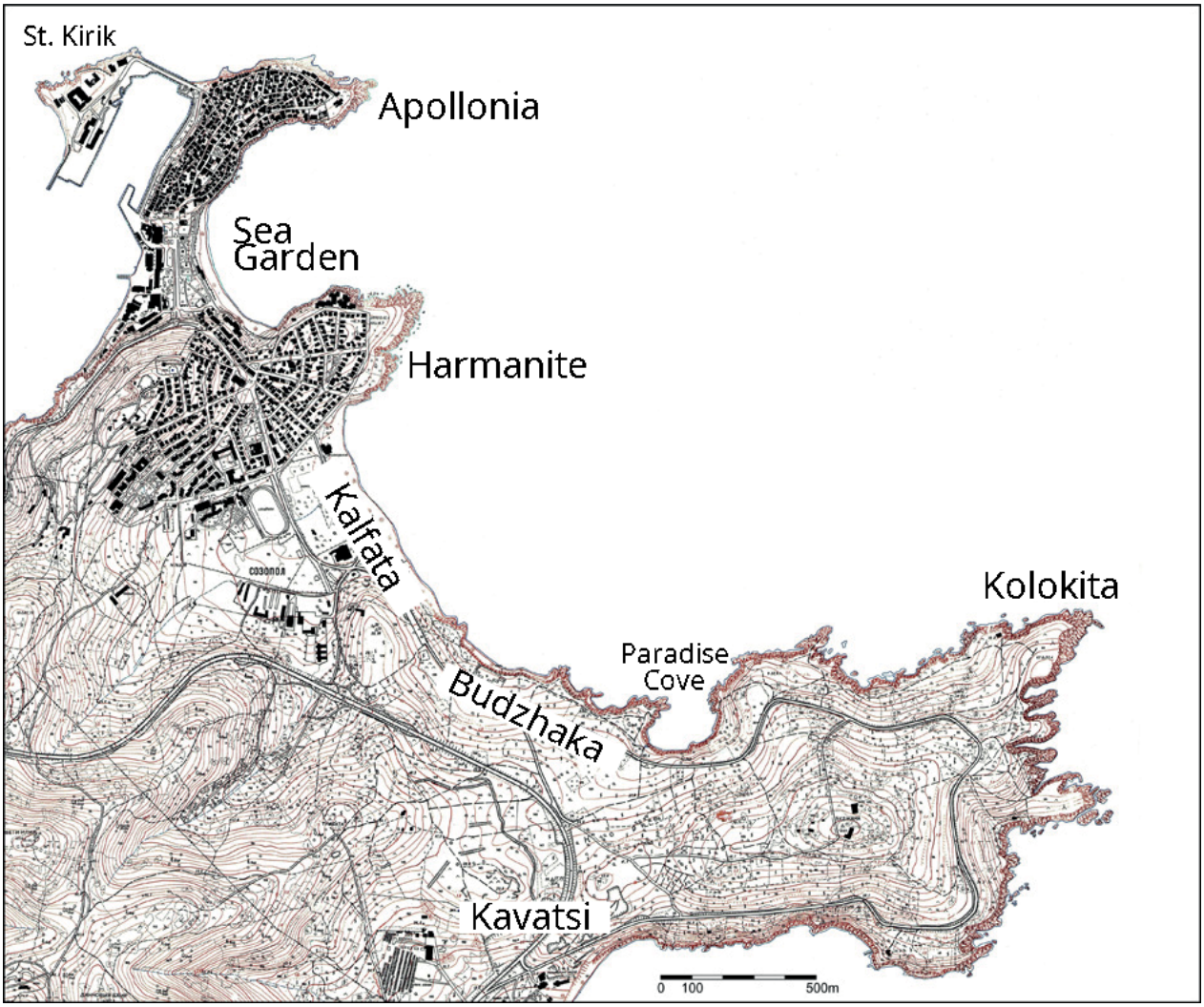

Fig. 6. Map of present-day Sozopol and its surroundings, with the location of the ancient city.

(Nedev/Panayotova 2003, 99; Panayotova et al. 2014, 596 f.; Недев 2016, 44 f.).

Strabo's description indicates that the main temenos with the sanctuary of Apollo was on the island of St. Kirik, but the inconclusive results of excavations in the early 20th cent. (Seure 1924, 320–323) led to other hypotheses about its location, such as on the island of St. John or the peninsula (see Nedev/Panayotova 2003, 97 f.; Gyuzelev 2008, 122 f.). The new investigations on St. Kirik solved this problem: among the uncovered architectural remains, there are a temple and a large altar, dated to the end of the Archaic period, the late 6th cent. BC (Панайотова et al. 2010; Panayotova et al. 2014, 595 f.; 2015, 296 f., Figs. 1–2) (*fig. 7*). The temple in Ionic order, probably with two columns in antis, was a modest building, with preserved dimensions of 11.75m by 6.8m. The platform of the altar in front of it was square, with a side length of 5.8m. The same building material was used for both structures, large blocks of *muschelkalk*, indicating they were constructed at the same time.

Bothroi with votive gifts reveal the functioning of the temenos already before the construction of the temple, most probably already from the late 7th cent. BC on. The association with the eponymous deity Apollo Ietros (the Healer) was confirmed by the discovery of a mid-6th cent. BC cup with a graffito: '[…]nas dedicated me to Apollo the Healer. From Knidos' (Martinez et al. 2015, 298, cat. 254) (*fig. 8*).

The excavations on the island of St. Kirik for the first time uncovered remains from Archaic Apollonia on a larger area and allowed for distinguishing two main phases (Panayotova et al. 2014, 595 f., Fig. 1). The first one comprises the late 7th and most of the 6th cent. BC and is characterised by



Fig. 7. The Late Archaic temple and altar on the island of St. Kirik.



Fig. 8. Archaic cup with a dedication to Apollo the Healer from the island of St. Kirik (mid-6th cent. BC).

modest dwellings (up to 20 to 25m^2) with mudbrick walls on stone foundations and roofs of perishable materials (*figs. 9–10*). A few sunken structures were also detected. Nonetheless, the early houses have the same orientation, indicating a general plan; a main (?) street, 3m wide, was discovered (*fig. 11*).

In all investigated contexts (pits and remains of buildings) from the first phase, there were traces of metallurgy, most of all a huge amount of slag from copper smelting. Pieces of slag were used as an insulation for the floors of some of the early houses (already from the first half of the 6th cent. BC) (*fig. 12*). A similar practice has been registered in the early levels of habitation on the peninsula. In the western part of the excavated area, a bipartite structure may be identified as a metalworking workshop. The earliest materials date it to the end of the 7th or the very beginning of the 6th cent. BC (*fig. 13*).

In the early period, the temenos appears to have been smaller, without evidence of stone architecture. This situation changed in the last quarter of the 6th cent. BC, when the dwellings in this part of the island were abandoned and demolished in order to open space for a much larger sacred precinct, where monumental structures were built: a temple and an altar (the latter overlays partly one of the earlier houses). The chronology is based on a *geison* block and eaves tiles and antefixes (Panayotova et al. 2014, 596, Fig. 2) with parallels in Miletos and Didyma (Busching 2013, 78 f., Taf. 18; Schneider 1996, 97–103, Abb. 74–76, Taf. 57–63, 102, 3–4); they add to the distribution of Archaic Milesian architectural terracotta in the Black Sea region (see Zimmermann 2007).[3] It was a process that developed for several decades. Ceramic plaques with relief depictions of warriors (Martinez et al. 2015, Cat. 255–256) (*fig. 15*) belonged to the decoration of an unidentified building from ca. 500 BC. New analyses indicate that another temple, that was built immediately to the east of the Archaic one and was previously given an Early Hellenistic date based on roof tiles (Panayotova et al. 2015, 296), should be dated in

3 Analysis of Daniela Stoyanova, Sofia University.

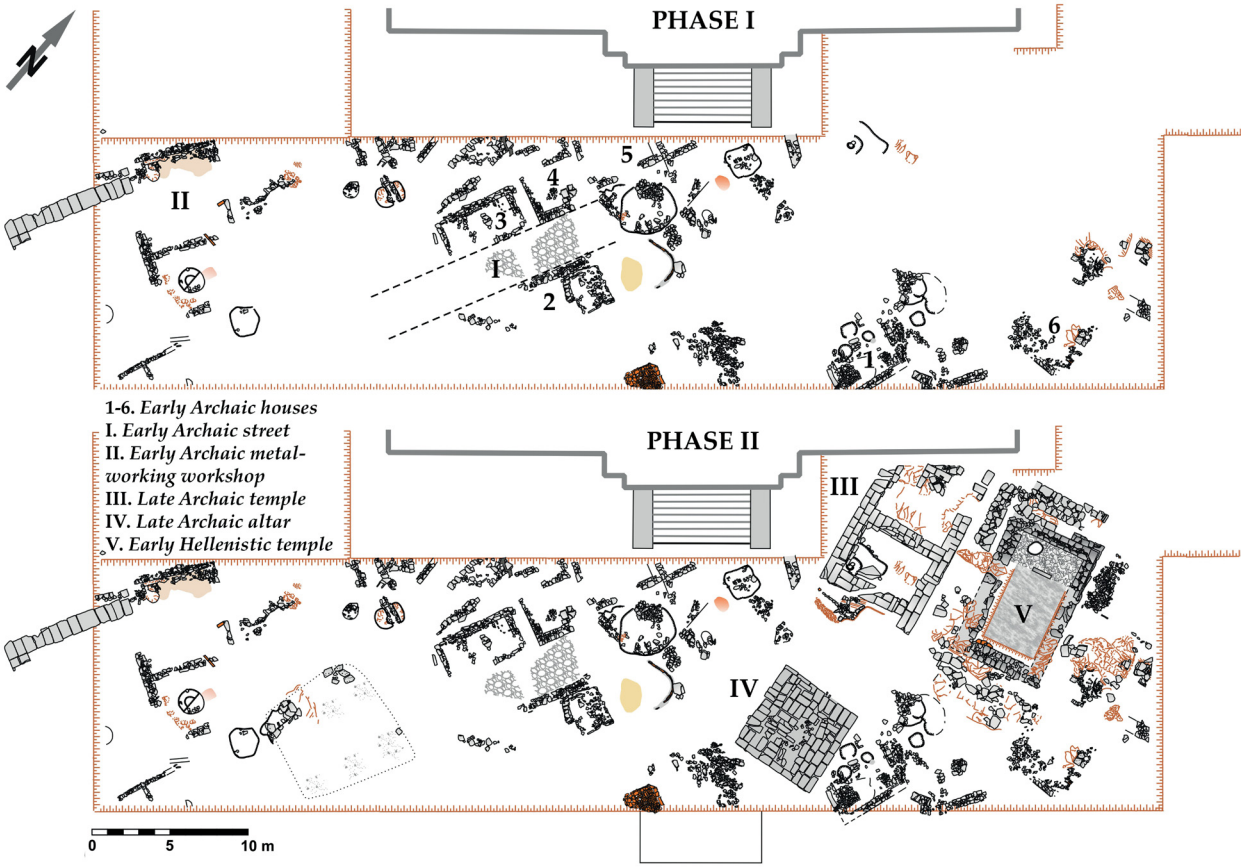

Fig. 9. Plan of the excavations on the island of St. Kirik with the two main phases in the Greek period.



Fig. 10. Dwelling No. 1 on the island of St. Kirik (first half of the 6th cent. BC).



Fig. 11. Part of the Archaic street on the island of St. Kirik.



Fig. 12. Pieces of slag used as insulation for the floor of Dwelling No.1 on the island of St. Kirik.

the first quarter of the 5th cent. BC. Architectural details attest to the existence of other structures within the temenos, such as limestone and marble altars, also dated to the first quarter of the 5th cent. BC (Panayotova et al. 2014, 596, Fig. 2; Stoyanova/Damyanov forthcoming) (*fig. 14*).

The break with the previous phase is made evident by the different orientation of the new buildings that could be seen in other structures on a large area (see *fig. 9*). These changes in the appearance of Apollonia could be considered a 'monumentalisation phase' about a century after the city's foundation, a phenomenon that is observed in other Pontic colonies, including the temenos of Istros (Avram 2003a, 320–322; Alexandrescu 2005, 66–86, Figs. 1.1–3.1).

It has been suggested that the construction of the first fortifications of Apollonia should be related to the monumental phase of the late 6th and early 5th cent. BC (Panayotova/Nedev 2015, 302), but still no positive traces from them have been identified. At present, the earliest testimony remains the mention of city gates by Aeneas Tacticus (20, 4) from the 4th cent. BC.

The observations presented above allow for the conclusion that Apollonia developed successfully in the first century of its existence, accumulating demographic potential and wealth. The

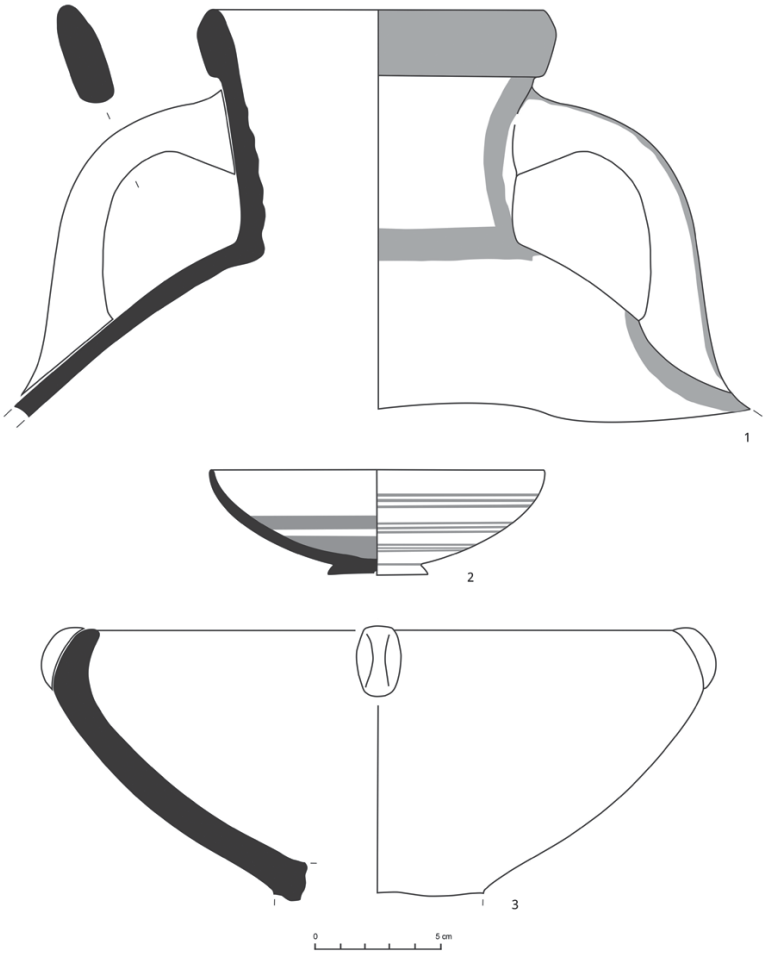

Fig. 13. Pottery from the so-called 'metalworking workshop', late 7th/early 6th cent. BC.



Fig. 14. Marble architectural details of Late Archaic altars.



Fig. 15. Ceramic plaques with relief decoration from a frieze of a Late Archaic building.



Fig. 16. Metallurgical kilns on the isthmus outside the ancient city, later 6th cent. BC.



Fig. 17. Skamni promontory at the north-eastern end of the peninsula of Sozopol's Old Town.

evidence about its territory and the relations with the local population indicates the same (see below). Apparently, metallurgy played an important role in the city's economy. Traces have been uncovered in other places on the peninsula of Sozopol's old town (Nedev/Gyuzelev 2010, 37 f.; Baralis et al. 2016, 159), including a complex of kilns in the northern end of the isthmus that connects it to the mainland, immediately outside the ancient city (*fig. 16*). They are dated to the second half of the 6th cent. BC and reveal the creation of production areas *extra muros* (a slightly later pottery kiln was also discovered) (Baralis/Panayotova 2015, 964–966, Fig. 6; Baralis et al. 2016, 159, Figs. 6–7).

The remaining evidence about the Archaic urbanism of Apollonia on the territory of the peninsula of Sozopol's old town is very fragmentary. Only rescue investigations have been carried out, limited by the needs of modern construction works, and the results only rarely were published in more details (see Baralis et al. 2013). They indicate that the organisation of the urban spaces followed the natural terrain and topography of the peninsula, without a comprehensive orthogonal plan, but with separate neighbourhoods with their own orientation (Nedev/Gyuzelev 2010, 36; Baralis et al. 2016, 156).

Observations on the Archaic pottery from Sozopol's old town indicate a higher concentration in the central and southern parts and lower to the north, probably due to the more unfavourable conditions because of the northern winds (Nedev/Panayotova 2003, 99). The impression about a less intensive habitation of the northern end of the peninsula is corroborated by the discovery of a sanctuary of Demeter on the Skamni promontory (*fig. 17*), functioning already from the first half of the 6th cent. BC. The identification is based on the votives: terracotta figurines, mainly of females (*fig. 18*), miniature vessels for liquids and *kernoi*, artefacts that were typically dedicated at such sites in the Greek world (Панайотова 2013; Damyanov 2016). The location is also revealing, as the secret nature of the female rituals honouring Demeter (for example during the Thesmophoria) required a secluded place, away from other public



Fig. 18. Terracotta figurines from the sanctuary of Demeter on Skamni peninsula.

spaces and residential areas (see Schipporeit 2013, 245–250).

Inscriptions, graffiti on vases and other finds from Apollonia also attest the worship of Aphrodite, Gaia, Hecate, the Great Mother and Dionysos (see Nedev/Panayotova 2003, 102 f.; Nedev/Gyuzlev 2010, 34 f.).

The monumental phase from the end of the Archaic period on the island of St. Kirik sets the stage for the appearance of the 13m high bronze statue of Apollo by Kalamis (Str. 7, 6, 1; Plin., N.H, 34, 17) in the second quarter of the 5th cent. BC (Mattusch 1988, 140 f.). The huge amount of metal that was needed for the colossus is a clear indication that Apollonia still controlled the ore deposits of Medni Rid despite a recently voiced hypothesis that metallurgy declined at the turn of the 5th cent. BC (Baralis et al. 2016, 176). Another sign of the city's prosperity in the 5th cent. BC is the appearance of silver coinage that replaces the so-called 'arrowhead-money' from the previous century (Karayotov 2007, 127–131).

Although the city itself is poorly known, important information about Apollonia in the 5th and 4th cent. BC could be obtained from the development of its necropolis (*fig. 19*). From the 1940s to present day, more than 2500 graves have been investigated, about one third of them published (Венедиков et al. 1948; 1963; Hermary et al. 2010; see also Nedev/Panayotova 2003, 123–140; Panayotova 2007). The huge majority date to the Classical and the Early Hellenistic period.

The necropolis of Apollonia developed mainly along a road that led from the peninsula to the south: crossing the isthmus (present-day Sea Garden park), along the north-eastern and the south-eastern slopes of the high hill across the city (the Harmanite neighbourhood of Sozopol's new town), then to the south-east following the shore of an open bay with a beach in the northern part (Kalfata locality). Then the coast becomes higher and rocky, and to the south of the bay, there is a large peninsula (Budzhaka), ending with the Kolokita promontory. The archaeological investigations were able to trace the ancient road for more than a kilometre in the Kalfata and Budzhaka localities (*figs. 20–21*).

The Archaic period remains poorly known. Recently, in the immediate vicinity of the city, several graves were discovered, dating from the first

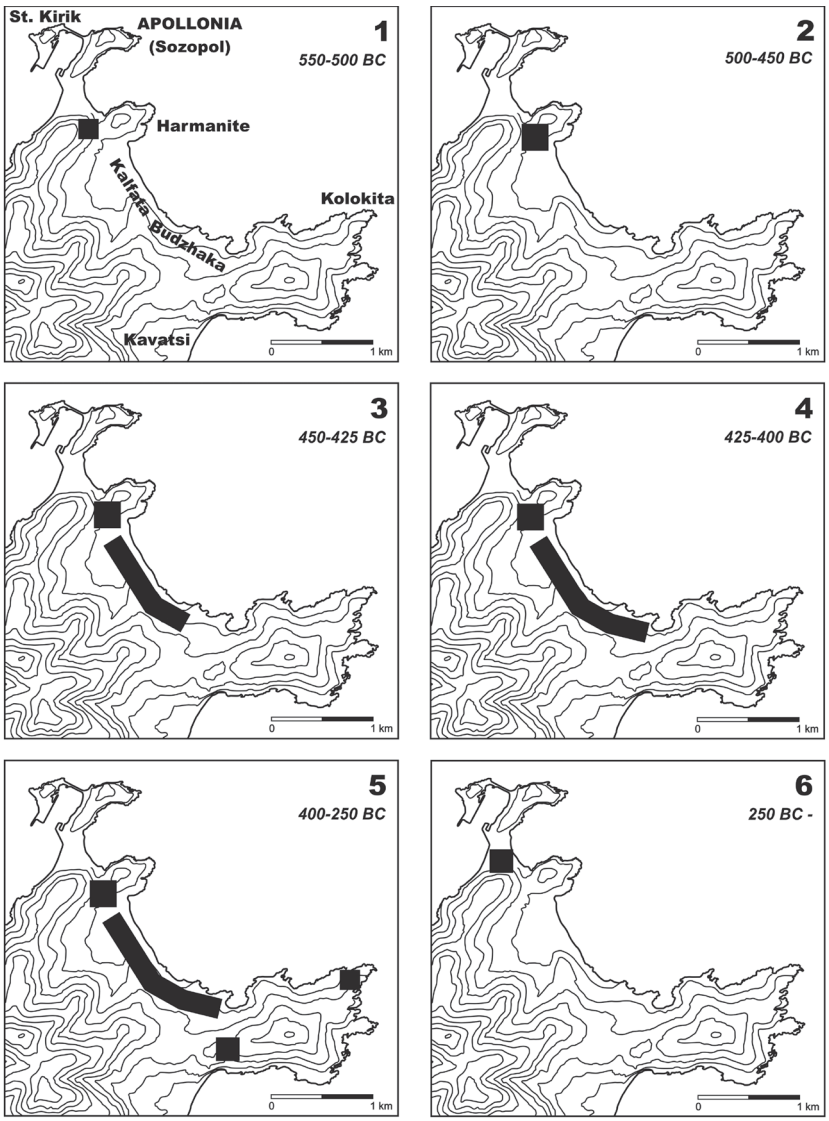

Fig. 19. Schematic presentation of the development of the necropolis of Apollonia from the Archaic to the Hellenistic period.

generation of colonists, that is from the late 7th to early 6th cent. BC (Дражева/Недев 2013, 469 f.; Baralis et al. 2016, 156–161). Around the middle of the 6th cent. BC, the necropolis had already reached the north-eastern slopes of the hill of the Harmanite neighbourhood. Excavations in the 1960s have yielded some early vases (Лазаров 1990, No. 3; Oppermann 2004, Taf. 10.1a–b). In the first half of the following century, it descended down the southern slopes of the same hill (see Иванов/Недев 2014; 2015; Панайотова et al. 2014b; Дамянов et al. 2015).

The middle of the 5th cent. BC marks the beginning of an entirely new period in the development of the funerary spaces of Apollonia. Within the third quarter of the century, a more than one-kilometre long strip along the coast in the Kalfata and Budzhaka localities was occupied by an extension of the necropolis, practically doubling its territory, and some 300m were added by the end of the 5th cent. BC, reaching present-day Paradise Cove (Damyanov forthcoming).

This is the most extensively investigated part of the necropolis of Apollonia, covering the period from the middle of the 5th to the middle of the 3rd cent. BC. There are several important publications, allowing for only a summary presentation of the funerary practices. Inhumation is almost exclusively dominant, with only about 3.6% cremation graves, the earliest known dated to the middle or the third quarter of the 5th cent. BC, with a visible increase after the middle of the 4th cent. BC and most of all in the Early Hellenistic period. Another specific is the considerably higher concentration

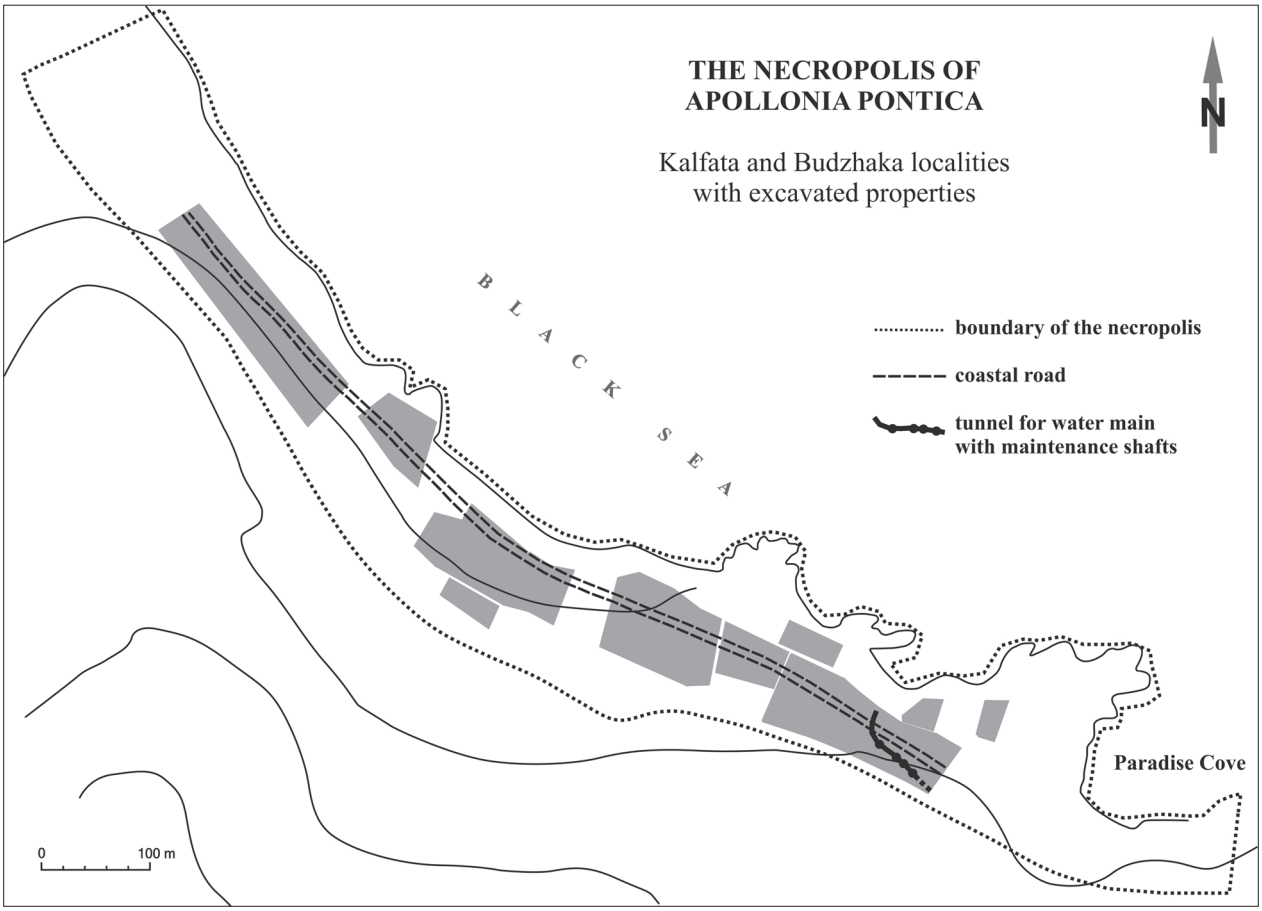

Fig. 20. Schematic plan of the necropolis in the Kalfata and Budzhaka localities, with the route of the ancient road and the tunnel for the water main.



Fig. 21. Part of the ancient road in the Kalfata locality, with burial enclosures on both sides.

of cremations in some parts, probably due to family preferences (Panayotova et al. forthcoming). Simple pits are most numerous throughout the period, and the earliest stone cists date from ca. 400 BC. They are also unequally distributed in the necropolis, possibly indicating different levels of wealth. Graves of roof tiles become widespread in the Hellenistic period. The inventory is typical

of a Greek necropolis: containers for scented oils (lekythoi and unguentaria), drinking vessels, toilet accessories (strigils, mirrors), and others.

The sudden expansion of the necropolis after the middle of the 5th cent. BC creates the impression of a one-time act by the polis. In addition, the investigations of large areas of the necropolis allow for distinguishing family plots, particularly visible in the first half of the 4th cent. BC, when low stone walls were built to delimit them (see Baralis/Panayotova 2013). This fact again suggests a thorough reorganisation of the funerary space.

One of the possible reasons for these transformations could be a demographic surge (too sudden to be the result of natural population growth). As already mentioned, Aristotle's Politics mentions such an event: the arrival of *epoikoi* (additional settlers) in Apollonia and ensuing strife in the city (Arist., Polit. 5.3. 1303a). These new settlers could have contributed to the presumed demographic surge. A. Avram connected this episode with the information about Anaximander as leader and dated it to the middle of the 6th cent. BC (Avram 2012, 201–205), but there seems to be more reason to relate it to the large-scale transformations in the archaeological situation a century later (see Hermary et al. 2010, 15). The local historical context seems to be fitting: this is a period of apparent economic prosperity for Apollonia and the city could afford inviting more population to strengthen its positions.

Indirect support for such a scenario could be found in the presumed reforms in the funerary sphere. The study of the funerary monuments from Apollonia gave rise to the hypothesis about the introduction of regulations to limit ostentatious funerals (Петрова 2010, 265–269; Petrova 2015, 138). It is based on the absence of funerary reliefs after the very beginning of the 5th cent. BC and the well-known monument of Deines, son of Anaxander, 'the noblest of the citizens' (Petrova 2015, 166–168). It continued to the early 2nd cent. BC, having in mind that funerary reliefs from the 4th to the 3rd cent. BC are known from all other *poleis* in the region (Petrova 2015, passim). Such a change could be explained with the internal struggles after the arrival of the *epoikoi*, mentioned by Aristotle, or with the change of Apollonia's government from oligarchy to democracy (Arist., Polit. 5, 6, 1305b),



Fig. 22. Limestone quarries in the Budzhaka locality, in the area of the necropolis, 5th cent. BC.



Fig. 23. Limestone quarries in the Budzhaka locality, in the area of the necropolis, 5th cent. BC.

which again cannot be dated with any precision (the only terminus is the composition of 'Politics' in mid-4th cent. BC). The change of constitution could have happened under Athenian influence: Apollonia was a member of the Delian League and its name is convincingly reconstructed in the tribute lists for 425/424 BC (IG I^3, 71, IV.128).

Despite these internal disturbances in Apollonia in the 5th cent. BC (possibly already in the first half of the century), the general impression is about a lasting prosperity. There are more signs of it in addition to the already commented bronze colossus of Apollo. In the southernmost part of the 5th cent. BC necropolis, traces of a limestone quarry have been detected (Панайотова et al. 2014c, 278, Обр. 3) (*figs. 22–23*), probably predating the first graves from the last quarter of the century. In the same area, an ambitious engineering project was



Fig. 24. Tunnel dug into the limestone for laying the pipes of a water main.

also brought to light: a tunnel for laying a water main of clay pipes dug in the soft limestone (*fig. 24*, see *fig. 20*) with service shafts at regular distances (Панайотова et al. 2008, 317; 2014c, 278). More than 80m of the tunnel have been traced, while its total length remains unknown; the water main itself is traced over more than a kilometre. The construction of the tunnel also seems to predate the expansion of the necropolis here.

The necropolis of Apollonia reached its largest area in the first decades of the 4th cent. BC, when graves appeared on the southern side of the peninsula of Budzhaka, facing the bay of Kavatsite. In this period appears the tumular necropolis on Kolokita promontory, where several unusual complexes have been investigated. At least two tumuli with numerous amphorae (more than 120 in one case) deposited in and around them could be dated to the first quarter of the century (Damyanov 2005, 214–216; 2011; Petrova 2011; Bozkova 2011). It appears that the place was deliberately chosen because of its enhanced visibility; while the high hill of the Harmanite neighbourhood practically hides the necropolis in the Kalfata and Budzhaka localities, there is a beautiful view from the ancient city to the Kolokita promontory. Various interpretations are possible: the promontory could have served as a place for burying individuals with special merits to the polis (Панайотова 1994, 85), or they could have been representatives of Apollonian aristocracy, seeking a way to circumvent the limitations of the presumed funerary regulations (Damyanov 2012, 51–53).

All evidence indicates the stability and prosperity of Apollonia during the Classical period, at least to the middle of the 4th cent. BC and possibly somewhat later. The large necropolis continues to exist in the second half of the century and the first decades of the 3rd cent. BC, but the Early Hellenistic period brought changes to the region.

The emergence and the upward development of Apollonia in the Archaic and the Classical periods raise the question about its *chora*: farmland, other resources, and satellite settlements under the control of the polis that supported its economic existence. The topic has been discussed in the literature (Nedev/Panayotova 2003, 107–119; Gyuzelev 2008, 132–138)[4], and the 'Inventory of Archaic and Classical Greek Poleis' assigned the territory of Apollonia to the fifth category: 500km^2 or more (Avram et al. 2004, 931, No. 682). While such a reconstruction could be challenged (see De Boer 2002, 137), archaeological investigations in the last decade led to a considerable increase of the data about the scope and the development of the *chora* of Apollonia in different periods.

The information that could be obtained from ancient written sources is scarce and controversial. Strabo (7, 6, 1) mentions Anchialo on the northern coast of Burgas Bay as a settlement (*polichnion*) of the Apollonians. This is confirmed by a Hellenistic inscription (ISM I 64 = IGBulg. I^2 388bis) describing Anchialo as a fort (*phrourion*); the decree is the only document mentioning the term *chora* related to Apollonia, and Anchialo belongs to *peran chora* 'the territory beyond/across' (in this case on the opposite shore of the bay). Another piece

4 This part of the text is authored by M. Gyuzelev.

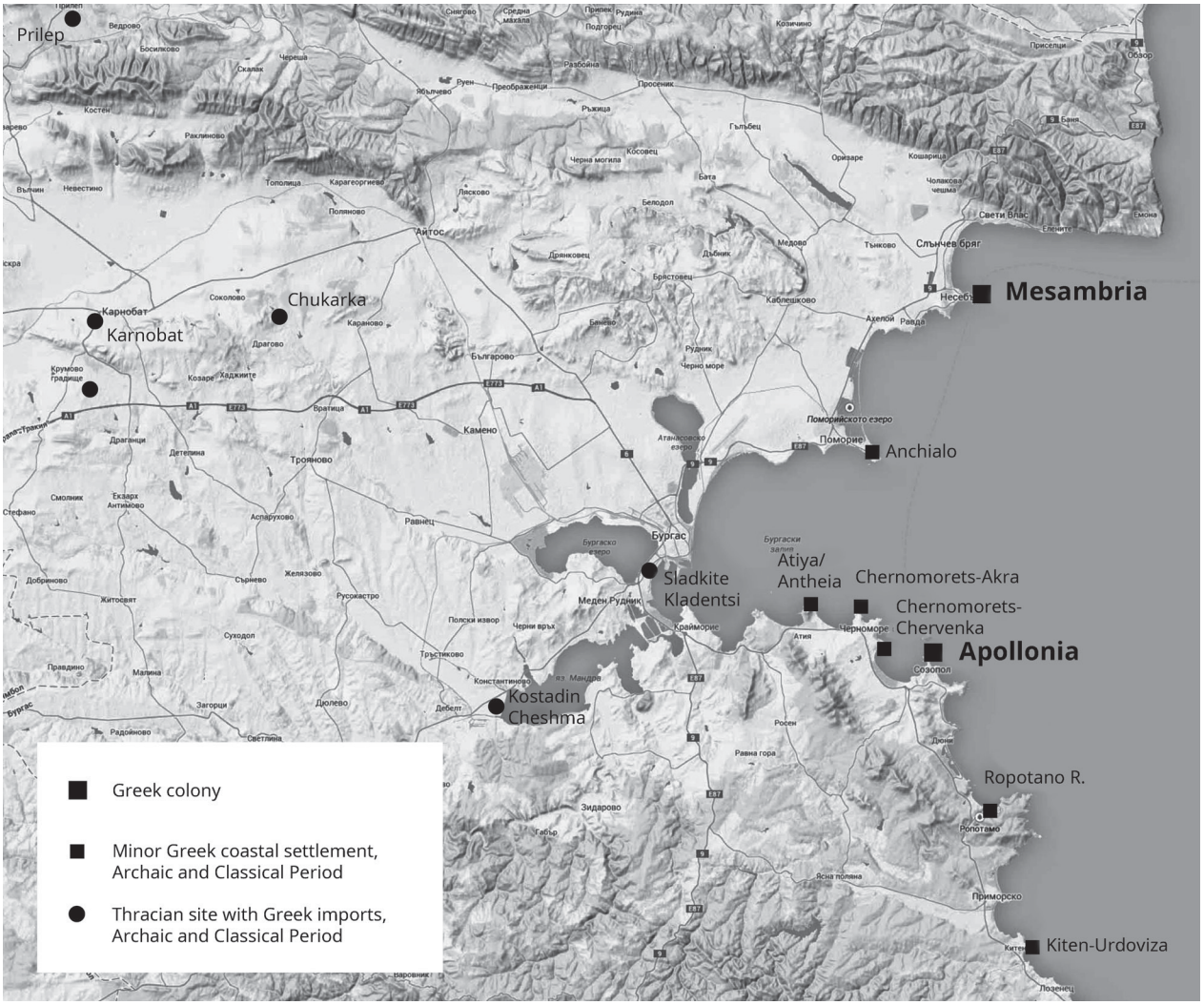

Fig. 25. The region of Apollonia in Archaic and Classical times: Coastal Greek (?) settlements and Thracian sites with Greek imports.

of evidence in the same passage of Strabo is more controversial: he assigns Thinias (modern Igneada in Turkey) to the territory of Apollonia, partly supported by Pseudo-Skymnos (728–730). This would mean that Apollonia controlled some 120km of the coast, which appears to be improbable having in mind the potential of the city. Probably, one should remember distinguishing the 'narrow' and the 'broad' meaning of the term *chora*: the actual land possessions of the polis and something that could be defined as 'zone of influence' respectively (Lepore 1968, 30 f.; 1973, 21).

A look at the topography of the region is sufficient to suggest the probable limits of the 'near' territory of Apollonia. The chain of Medni Rid encompasses a narrow coastal plain with a few hilly areas, between the Atiya promontory to the north and the mouth of the Ropotamo to the south, with Apollonia situated practically in the centre (see *fig. 25*). Logic dictates that the properties of the citizens were precisely in this area: in the plain to the north of the city, and to the south in the interior around present-day Ravadinovo (Nedev/Panayotova 2003, 100; Gyuzelev 2008, 134).

At present, it is difficult to specify the time of the creation of the Apollonian *chora*, although some mostly indirect data hint at a very early moment in the Archaic period. Among them is the evidence of early metallurgy from the city itself (see above), indicating that the copper deposits of Medni Rid along the western border of the outlined territory have been mined at latest from the early 6th cent. BC on, within the first generation of colonists. This is supported by Archaic fragments

collected from the area of the mines (Лещаков/Класнаков 2011, 584). Such a development presupposes some kind of control on the surrounding territories and some kind of agreement with the local population.

Although not numerous, the early materials from the Atiya promontory reveal an important Archaic settlement that continued to exist until the Hellenistic period (Gyuzelev 2008, 116 f., 266 f.). Among them is a marble Ionian draped kouros from the late 6th cent. BC (see Oppermann 2004, 37 with references; Martinez et al. 2015, Cat. 253), still unique for the Western Black Sea coast. A hoard of 'arrowhead-money' found together with a mould for casting them speaks of metallurgy and interest towards the Rosen ore-field nearby (see Черных 1978, 19–23). The status of the settlement, especially early in the Archaic period, remains unclear. For a long time already, it is accepted to identify Atiya promontory with Antheia, mentioned in the sources as a colony of Miletos and Phokaia (Steph. Byz., Ethnica: Ἄνθεια; Plin., N.H. 4, 11, 45; see Avram et al. 2004, 929), which fact suggests an early foundation. However, there is no evidence from later periods to indicate that Antheia developed as an independent polis. It is not mentioned in narrative sources or epigraphic monuments, and no coinage has been associated with it. It seems logical to assume that the settlement was included at some point in the territory of Apollonia, possibly by means of synoecism (Oppermann 2004, 12).

The presumed coexistence of Apollonia and Antheia for some time hints at a possible comparison with the north-western Black Sea area, where two similar cases have been studied: Orgame and Istros in northern Dobrudzha and Borysthenes/is (the island of Berezan) and Olbia in the Dnieper-Bug estuary (see Alexandrescu 1999; Буйских 2013). In both cases, the earlier settlement (Orgame and Borysthenes/is) is not attested as an independent polis in the Classical period and later. It has been suggested that Borysthenes/is (and possibly Orgame) emerged with mainly commercial functions and were later replaced by centres that were founded with the aim to control more land and resources (respectively with larger demographic potential). Antheia and Apollonia could fit within such a scenario: the former had access to limited farmland, but was close to ore deposits and to the navigable estuaries of Burgas Bay that provided communication with the Thracian interior; on the other hand, the location of the latter gave control over a much larger territory, in addition to the excellent harbour.

At present, there are more explicit data for permanent occupation of the adjacent territory of Apollonia from the Classical period. In the last few years, evidence emerged about Classical sites in the surroundings of modern Chernomorets between Apollonia and Antheia (see Gyuzelev 2008, 117, 266). Imported pottery from the 5th to the 3rd cent. BC (Девлова 2014, 51 f.) and contemporary roof tiles (Киров 2014) and amphorae have been found in Vromos Bay, facing Atiya promontory. The site has been interpreted as an *emporion*[5] within the territory of Apollonia (Христов 2013, 199 f.), but it may be regarded just as a satellite settlement, related to the cultivation of the farmland in the area. Traces of another large settlement, possibly founded already in Archaic times, were detected on the Chervenka peninsula to the south of Chernomorets, facing Apollonia (Христов 2015, 21–26; 2017a, 23–50).

Although scarce and preliminary, the new data reveal a dense network of settlements along the coast between Apollonia and Antheia, with sites at suitable places at a few kilometres from each other. This situation reminds of what is known from other, better researched parts of the western Pontos, for example, the territories of Istros and Kallatis in Dobrudzha (Avram 2001; 2006). Such a network ensured an effective exploitation of the *chora* and its resources.

In 2010, a Bulgarian-French project for investigating the territory of Apollonia began and after a few seasons provided more detailed data about the city's expansion in Classical and Early Hellenistic times. The above-discussed development of the necropolis in the 5th and 4th cent. BC clearly illustrates the creation of new spaces in the period,

5 The bibliography on the meaning of the term *emporion* is enormous (among others Bresson 1993, Hansen 1997). For the sake of brevity, and in order to avoid a lengthy technical discussion, here it is used as a lesser coastal settlement dependent on a full-scale polis (Apollonia in this case) that could have had commercial functions. It is not meant as the administratively defined part of the city, dedicated to commercial operations.



Fig. 26. Ancient buildings at Mesarite locality at ca. 2km from Apollonia (photo: Loïc Damelet).

especially visible from ca. 450 BC onwards. At the same time or somewhat earlier, new sites related to the exploitation of the *chora* emerged in the close vicinity of the city. The earliest remains in the Mesarite locality on St. Marina hill at ca. 2km from Apollonia are dated to the first quarter of the 5th cent. BC (Baralis/Panayotova 2015, 983; Baralis et al. 2016, 168–170). From the second quarter of the century onwards, a large complex of structures develops on the hill and remains in use until the beginning of the 3rd cent. BC (Baralis/Panayotova 2015, 988–993, Figs. 14–15; Baralis et al. 2016, 171–174, Figs. 14–16) (*fig. 26*). The buildings were organised along a road that probably connected Apollonia with the territory to the north of it (*fig. 27*).[6] In the Early Hellenistic period (the first half of the 3rd cent. BC), a necropolis related

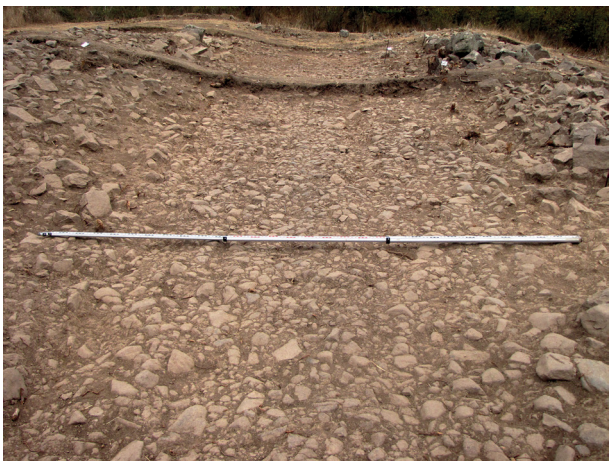

Fig. 27. Part of the uncovered ancient road through the Mesarite locality, with visible ruts.

to the settlement emerged nearby (Панайотова/Баралис 2018).

Not far, on the northern slope of the same hill, another structure has been investigated, most probably an individual farm, dated to the period from the middle of the 4th to the middle of the

6 Results from the ongoing investigations (see Панайотова et al. 2017, 244).



Fig. 28. Traces of ancient agriculture (vineyards?) on a hill above the necropolis in the Kalfata locality (photo: Loïc Damelet).

3rd cent. BC (Гюзелев/Господинов 2011; Гюзелев et al. 2012; Baralis/Panayotova 2015, 983–986, Figs. 11–12; Baralis et al. 2016, 170 f., Fig. 12).

Another new result from investigations in the immediate surroundings of Apollonia during the last few years is the detection of actual traces of agriculture. At several sites within two or three kilometres from the city, short shallow trenches arranged in regular rows were discovered covering a substantial area and dug into the clayey ground beneath the sandy topsoil (*fig. 28*). They could be interpreted as trenches for planting vineyards and the accompanying materials date them to Hellenistic times (see Панайотова/Дамянов 2016), but possibly also earlier (see Богданова et al. 2017a; Богданова et al. 2017b).

The new evidence considerably modified the picture of the Apollonian *chora* in the Archaic and Classical periods. There are sufficient grounds to presume the existence of more, not yet discovered sites, shaping the dense fabric of the adjacent territory of the polis.[7]

The narrow coastal plain to the east of Medni Rid provided poor agricultural resources, which was probably the reason for the growing

7 In 2017, initial investigations of a site near the village of Ravadinovo, at ca. 7km from Apollonia and in immediate proximity to one of the ancient mines of Medni Rid yielded very important results. The site is a hilltop fortress of square plan (ca. 85m by 85m) with an additionally fortified inner part (20m by 20m) in one of the corners. The stone walls, preserved up to 2m, are 1.6m to 1.8m thick. The materials (black-glazed pottery and amphorae) indicate that the fortress appeared before the middle of the 5th cent. BC and remained in use during the 4th cent. BC. We are grateful for the information to Pavlina Devlova, National History Museum, Sofia. Having in mind the growth of Apollonia in the first half of the 5th cent. BC and the developments observed at Mesarite, the fortress could be related to the establishing of a settled and guarded Apollonian *chora*. It would appear that the protection of the mineral resources was especially important.

Apollonian polis to search for more farmland elsewhere. Such an opportunity was offered by the '*chora* beyond' around Anchialo on the northern shore of Burgas Bay, 15km as the crow flies from Apollonia (and at 10km from Antheia). Despite the fact that the earliest mention of Anchialo as an Apollonian *phrourion* dates only from the 2nd cent. BC, the scarce archaeological data allow for a considerably earlier date, including in the Archaic period (Gyuzelev 2008, 95–97, 226–229). Some indirect observations also support such a hypothesis. On the one hand, Apollonia was on the rise in the 6th and 5th cent. BC and this is the period when one could expect a major expansion. On the other hand, the appearance of Anchialo as a satellite of Apollonia most probably predated the foundation of Mesambria as a second Greek colony in the region of Burgas Bay in the late 6th cent. BC. And finally, newly discovered materials from Urdoviza to the south (see below) attest the existence of coastal settlements, apparently related to Apollonia, already in the first half or the middle of the 6th cent. BC. Therefore, Anchialo most probably existed as an Apollonian 'enclave' since the Archaic period; there are no reasons to believe that Apollonia controlled the entire length of Burgas Bay, which, however, provided communications with the interior (see below). In the case of Anchialo, one should have in mind the direct visibility across the bay.

The borders of the Apollonian territory to the south are harder to trace. Ancient finds, including a North Ionian eye-cup from the first decades of the 6th cent. BC, have been discovered at the mouth of the Ropotamo (Karayotov 2002, 560 f.; Gyuzelev 2008, 136, 236). It has been suggested that an *emporion* of Apollonia existed here, identified as Cherronesos in the periplus of Arrian (Karayotov 2002, 562; De Boer 2002, 129 f.; De Boer/Stronk 2002, 235). The site is at the presumed southern end of the territory of Apollonia, and the location at the mouth of a navigable river could serve as an indirect argument in favour of commercial functions.

There are more data about ancient settlements at modern Kiten on the Urdoviza peninsula and near the mouth of the Kitenska river (former Karaagach) (see *fig. 25*). Based on a funerary monument from the 5th or 4th cent. BC (IGBulg. V 5155) found in the area, the latter site has been identified provisionally as a satellite settlement (*emporion*?) of Apollonia, named Perinthos (De Boer 2002, 128 f.; De Boer/Stronk 2002, 235 f.; Gyuzelev 2008, 229–231; for an opposing view see Karayotov 2002, 564–566). Moreover, the funerary monument with the names of a father and a son indicates long-term habitation. Therefore, G. Mihailov suggested the existence of a farm, owned by a citizen of Apollonia.

In 2012 and 2013, excavations of a limited area around the Late Antique and Medieval fortress wall at the Urdoviza peninsula (Панайотова et al. 2013; Даскалов/Панайотова 2015) brought to light numerous fragments of Archaic and Classical imported pottery, covering a long period from the 6th to the 4th/3rd cent. BC. The earliest fragments could be dated as early as the first half of the 6th cent. BC, and the Archaic ceramic assemblage is very similar to that from Apollonia (from the island of St. Kirik): numerous Aeolian and Ionian amphorae (Chios, Klazomenai, Miletos) (*fig. 29*), East Greek drinking vessels (*fig. 30*), etc. Pottery indicates the settlement also existed in Classical times, down to the beginning of the Early Hellenistic period (*fig. 31*). Among predominantly Greek materials, there are a handful of fragments from coarse hand-made jars with relief bands (*fig. 32*). A similar picture is also attested on the island of St. Kirik in the Archaic period (see below).

Despite their preliminary character, the results from Urdoviza are very important in respect to the development of Apollonia, as they illustrate the activity of the polis along a longer stretch of the cost, Kiten being at almost 30km to the south. The numerous Archaic materials for example provide indirect support for an early date for the foundation of Anchialo. On the other hand, the great distance and the difficult communications between Apollonia and Urdoviza raise the question about whether the latter could have been part of a continuous Apollonian territory. Some evidence speaks against such a reconstruction, at least for the Hellenistic period (see below). Another possibility is to see Urdoviza as a separate dependent settlement serving as a harbour along the coastal sailing route and probably controlling some farmland. Such an interpretation would make Strabo's information about Thinias more



Fig. 29. Archaic and Early Classical transport amphorae from the Urdoviza peninsula, Kiten.

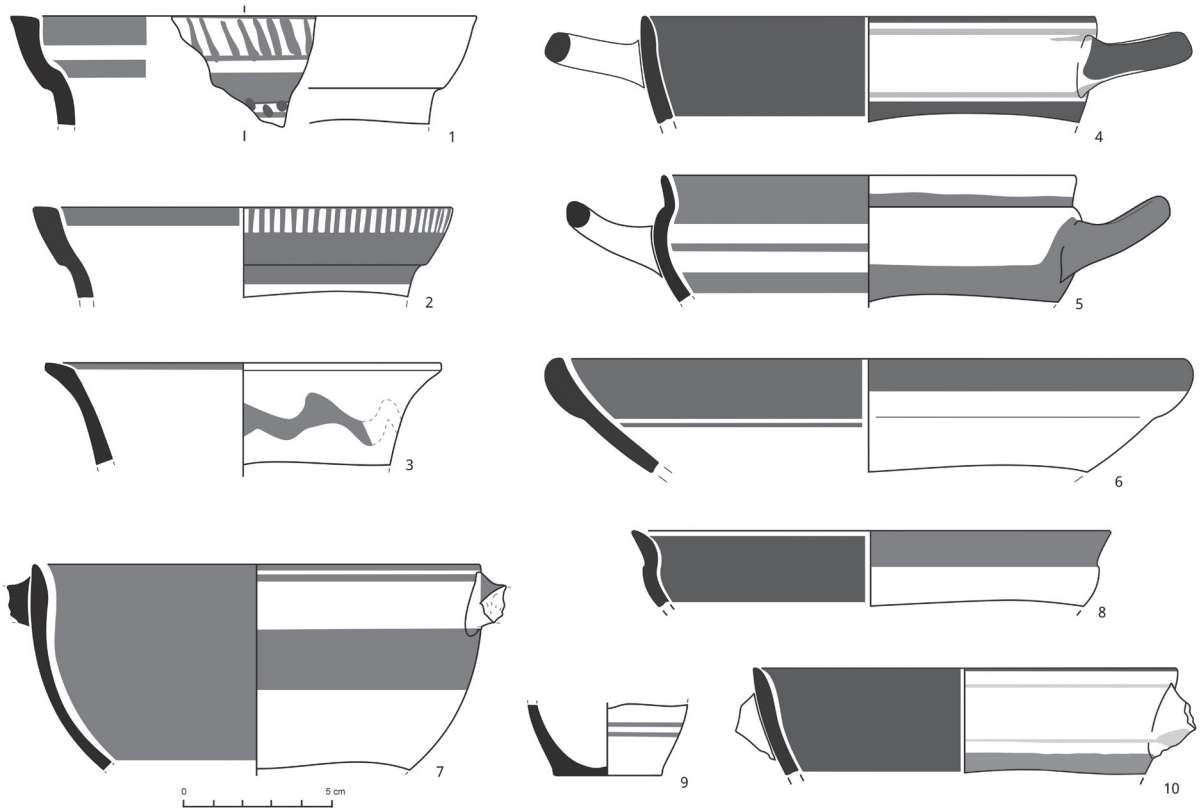

Fig. 30. Archaic East Greek pottery from the Urdoviza peninsula, Kiten.

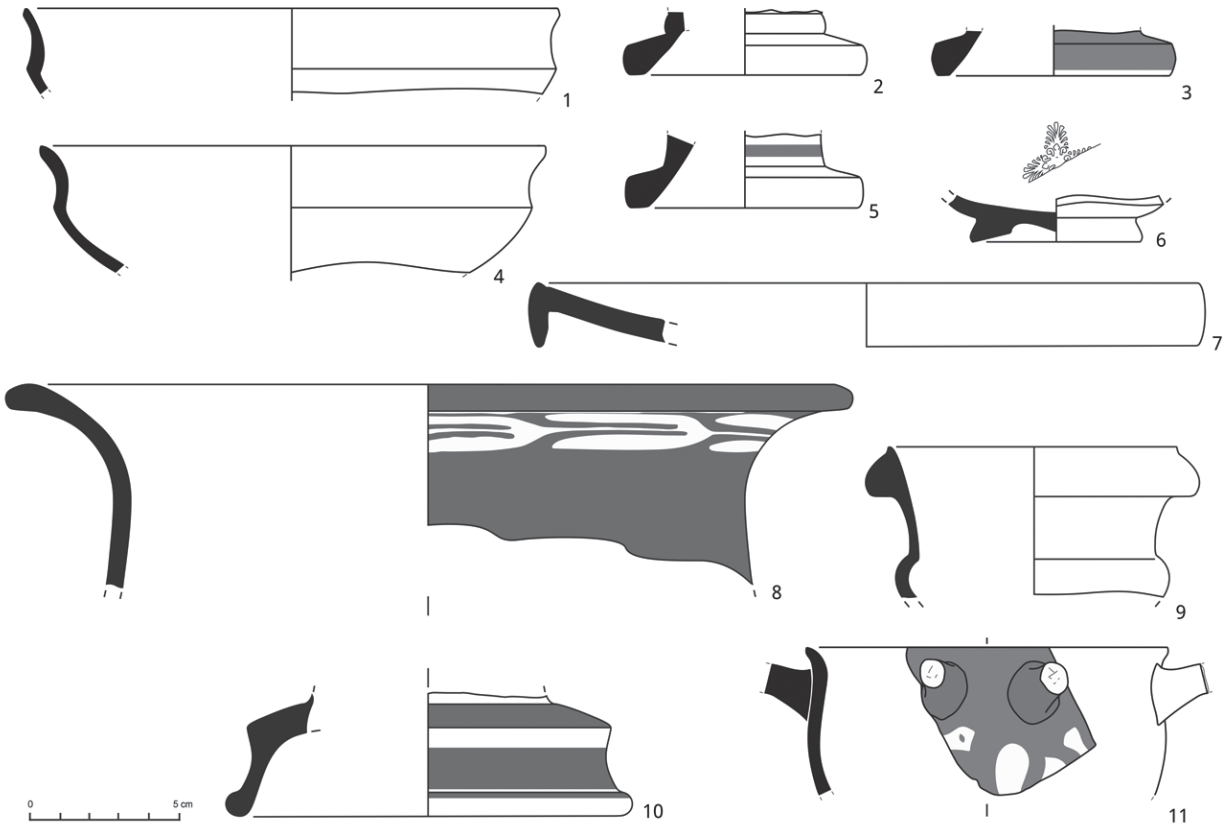

Fig. 31. Late Archaic and Classical pottery from the Urdoviza peninsula, Kiten.

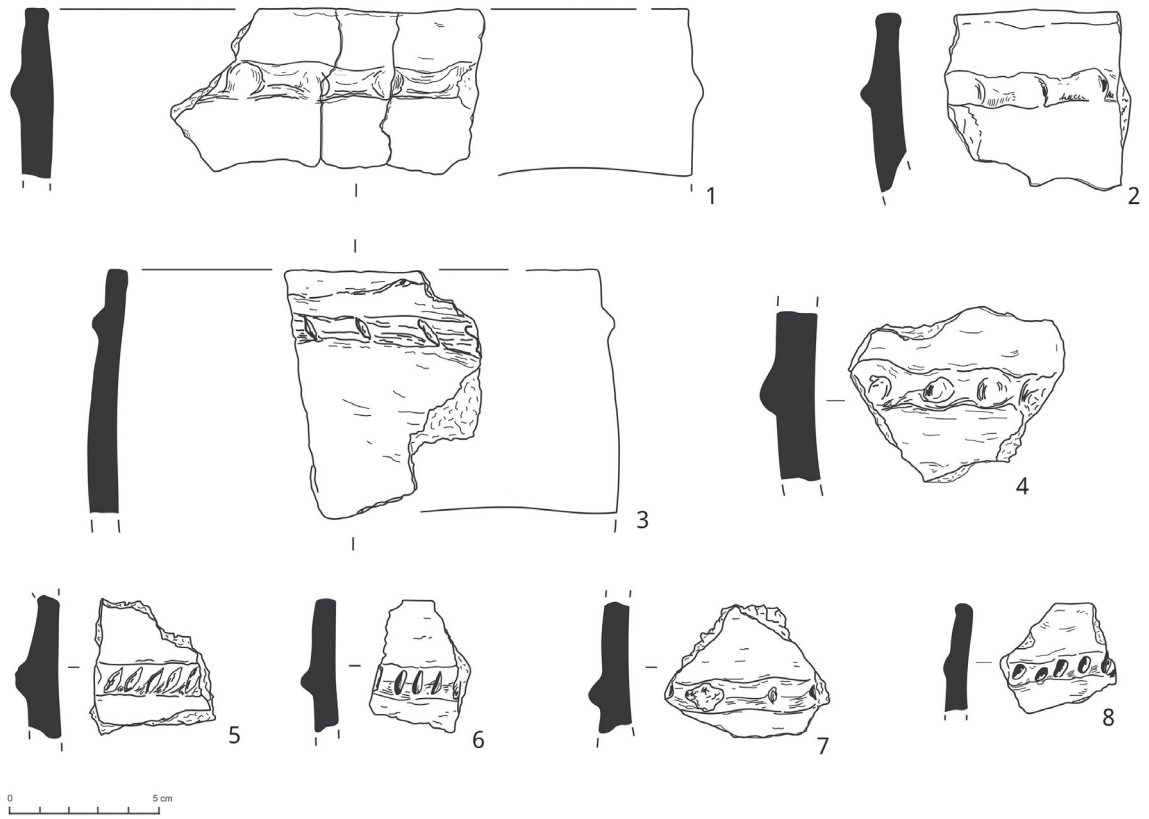

Fig. 32. Fragments of coarse hand-made jars from the Urdoviza peninsula, Kiten.

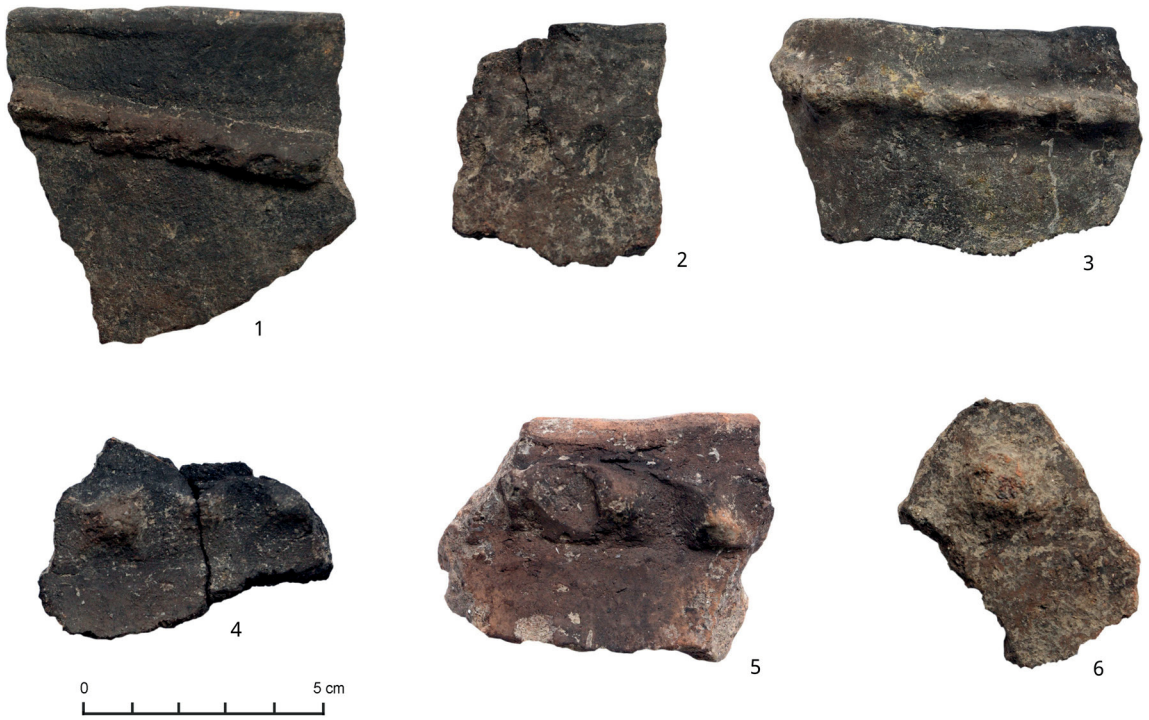

Fig. 33. Fragments of coarse hand-made jars from the island of St. Kirik.

credible as belonging to Apollonia; the polis could have controlled a network of small harbours along the 100km long coast to the south. They could have had commercial ('emporial') and other economic functions. This network might outline Apollonia's 'zone of influence'. The lack of detailed information allows for very limited speculations about the nature of these settlements. They should have existed with the consent of the local Thracians, and a mixed population cannot be excluded.

Another similar settlement may have existed at the site of modern Ahtopol – possibly Aulaiouteichos – known from the peripli (Arr., Per. Pont. Eux. 36). The archaeological material from the site is meagre (see Делев 1990, 145; De Boer 2005, 173–177; Gyuzelev 2008, 146–148) and the main discussion revolves around two Greek inscriptions found in the sea. One opinion regards them as evidence for a 5th cent. BC Athenian foundation, related to Perikles' Pontic expedition (Velkov 1994; De Boer 2005), while the other treats them as Apollonian decrees from the 3rd cent. BC (Avram 2002).

Observations on the territory of Apollonia naturally raise the question about its relations with the local Thracian population from the foundation of the colony to the Macedonian expansion in the third quarter of the 4th cent. BC that definitely changed the general historical setting.

The steady development of the polis through the Archaic and Classical periods is reflected indirectly in the connections with the Thracian hinterland. The moment of the first contact remains blurry, but as already mentioned, Apollonia could hardly have gained access to the metal riches of Medni Rid without the consent or even the cooperation of the local Thracians. The presence of fragments of hand-made vases of Thracian shapes already in the earliest contexts on the island of St. Kirik, as early as ca. 600 BC, confirms early contacts (*fig. 33–34*, see also *fig. 13*).

Already in the end of the 7th or the very beginning of the 6th cent. BC, Greek imports appeared at sites around Burgas Bay, for example at Kostadin Cheshma near Debelt (at the western end of the Mandrensko lake, a navigable estuary in ancient times) (Tzochev 2011) and illustrated the quick establishing of connections between the Greeks and the local population. In the first half and down to the end of the 6th cent. BC, an important concentration of imported goods is observed in the area

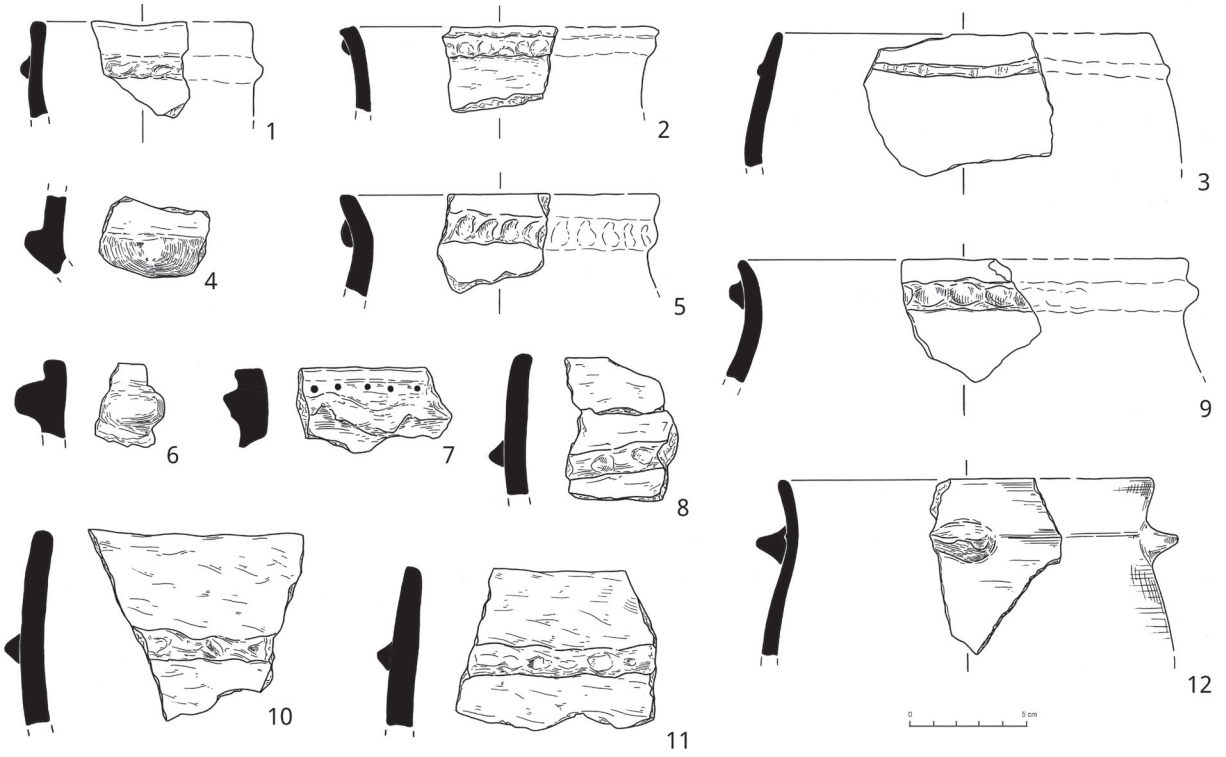

Fig. 34. Fragments of coarse hand-made jars from the island of St. Kirik.

of Karnobat, where the ceramic assemblage displays similarities with coastal sites on the Black Sea and particularly with Apollonia (Ников 2009, 118–120; Цочев 2009, 124 f.; Георгиева/Ников 2010, 142–149) (see *fig. 25*). The penetration of early imports could be traced at least to the region of modern Yambol (Караджинов 2012), where however the traffic from the Black Sea merged with the one from the northern Aegean coast (see Tzochev 2010, Pl. 56.1) and it is difficult to tell them apart.

The rise of the Odrysian Kingdom brought changes in Thrace, but the process apparently did not have negative effects on Apollonia. In the 5th cent. BC, a site emerged at Sladkite Kladentsi on the shore of Burgas Bay (Isaac 1986, 249; Oppermann 2004, 89 f.; Gyuzelev 2008, 98 f., 187–192); its location at the entrance of the navigable estuaries (lakes at present) and the abundance of Greek materials are the reasons the place to be interpreted as *emporion*. The pottery demonstrates clear similarities with Apollonia (see Oppermann 2004, 111–120). However, the necropolis of cremation graves near the settlement (Балабанов/Дражева 1985) suggests a mainly non-Greek (Thracian) population, an indication that the inner parts of Burgas Bay did not belong to the territory of Apollonia.

Materials from the region of Karnobat also speak of continuity (Ников 2009, 120 f.; Цочев 2009, 124 f.; Георгиева/Ников 2010, 149–153), and some symptomatic finds reveal direct connections with Apollonia. Among them are the two red-figure mugs (or small jugs) with Thracian warriors: one from Apollonia (Лазаров 1990, No 16; Reho 1990, No. 190) and the other from a tumulus near Karnobat (Георгиева 2005). For a long time, the first one was considered unique and was interpreted as a special commission by an Apollonian client (Lezzi-Hafter 1997, 359–365). The appearance of a second one, almost identical, in the Thracian hinterland seems to suggest special relations with the Pontic colony. Another similar case is presented by several *oinochoai* of VIII B type, another rare shape in the Attic red-figure pottery from the late 5th cent. BC: one from Apollonia (Панайотова et al. 2011, 266, обр. 3), one from Sladkite Kladentsi (Лазаров 1990, No 38; Reho 1990, No. 412) and two from the Svetitsata tumulus near Kazanlak (Kitov 2005, 35 f., Figs. 18–22).

These finds could trace Apollonia's interests deep in the Odrysian territories.

One may also add the observations on the distribution of the Herakleian *amphorae* (with englyphic stamps) in the first half of the 4th cent. BC. They are numerous in Apollonia (Gueorgieva 2001, 289–293; see Bozkova 2011; Damyanov 2011, 95–99) and represent the majority of the imports at Kostadin Cheshma (Balabanov 2011, 124; Balabanov et al. 2016), apparently a Thracian site with (redistributive?) commercial functions (and with continuity from the Archaic period). The area of domination of the Herakleian amphorae could be traced to the west to modern Nova Zagora, and it has been suggested that it marks the economic influence of Apollonia (Tzochev 2010, 99 f., Pl. 56.2). In the last few years, another Thracian site with numerous imports and Herakleian amphorae, in particular, was investigated near the village of Malenovo, Yambol region, and seems to confirm previous conclusions (Божкова et al. 2016; 2017).

The available evidence indicates that this favourable for Apollonia situation changed after the Macedonian expansion in the third quarter of the 4th cent. BC. It brought down the Odrysian Kingdom and modified the balance in the Thracian interior, with inevitable consequences for the political and economic ties of the Ionian polis.

Early Hellenistic Period

The Hellenistic period is among the poorest known in the history of the Black Sea coast to the south of the Balkan range, and of Apollonia and its hinterland in particular, which fact seems strange having in mind the important processes that unfolded in the ancient world and also affected more peripheral regions.

In fact, there is no information whatsoever about the period of the Macedonian domination over the region that lasted some six decades from the campaigns of Philip II to the death of Lysimachus in 281 BC. About 340 BC, Apollonia is mentioned as an intermediary between the Scythian king Ataias and Philip II (Just. Epit. 9, 2, 1; Делев 2004, 231–236; last in Лазаренко 2015, 128–141) and afterwards disappears from the sources. According to Arrian, in 323 BC Lysimachus received territories that reached to Salmidessos to the north, considerably farther to the south from Apollonia (Делев 2004, 343 f.). The presumption that the Diadoch relatively quickly took hold of the territories to the east of the river Tundzha and the Black Sea coast with Apollonia, Anchialo, and Mesambria (and established garrisons there) seems to be logical (Делев 2004, 150 f., 346 f.), but is not yet supported by any solid evidence.

For the following period, the scarce written sources focus on the Greek cities to the north of the Balkan range, mainly in the context of the revolt of Kallatis; Istros and Odessos are also explicitly mentioned (Diod. 19, 73). These events provide context also for the information of Tirizis (present-day Kaliakra) as a treasury of Lysimachus (Str. 7, 6, 1). Special attention should be paid to Odessos as the port used by Kassander to send reinforcements to Lysimachus before the Battle of Ipsos (Diod. 20, 112; Делев 2004, 182 f.): It remains unclear why Pleistarchos chose to cross the Balkan passes to Odessos, instead of opting for Apollonia or Mesambria that were closer. One of the possible explanations puts under question Lysimachus' control over the region of Burgas Bay.

Archaeology is unable to replace the lack of ancient sources adequately but provides some directions. Some changes in the traffic of Greek imports in the hinterland of Burgas Bay could be related to the campaigns of Philip II: for example the disappearance of Herakleian amphorae after the middle of the 4th cent. BC. As mentioned above, there are sufficient reasons to believe that Apollonia was behind this trade and the changes indicate disruptions in the ties of the polis with the Thracian interior that most probably had negative effects on its economy. In a slightly later period, this void seems to have been filled by Mesambria (see below).

Around the middle of the 4th cent. BC, a fortified site appeared on the northern shore of Mandrensko lake (Балабанов 1984; Gyuzelev 2008, 101–103). It had a rectangular plan, with one of the enclosure walls ca. 50m long and up to 1.5m thick (the rest was destroyed by the waters of the lake) with a tower protruding from it. The complex had a residential building, probably with rich decoration, and farm buildings. The site underwent reconstruction in the second half of the

3rd cent. BC and possibly existed into the early 2nd cent. BC. It has been interpreted as *tyrsis*, the centre of the domain of a rich Thracian family, but it is important to note that its emergence and first period could be dated precisely to the period of the Macedonian expansion in Thrace. As mentioned above, the situation in the region is particularly unclear, but another possibility would be to relate the site to the Macedonians, for example, as a residence of a local governor or of a nobleman who was endowed with lands in the area.

The available evidence from Apollonia itself and its immediate surroundings does not suggest any major disruptions related to the establishing of the Macedonian power and the inclusion of the western Pontic coast into the kingdom of Lysimachus. Preliminary observations date the reconstruction (with a new roof) of at least one of the temples in the temenos on the island of St. Kirik to the Early Hellenistic period. In the same period, the appearance of monumental buildings is registered in other *poleis* as well, for example in Odessos (Stoyanov/Stoyanova 1997) and Istros (Alexandrescu 2005, 109–127).

The evidence from the funerary spaces also indicates stability: the use of the large necropolis in the Kalfata and Budzhaka localities continues without visible interruptions in the second half of the 4th and the first decades of the 3rd cent. BC. In the first half of the 3rd cent. BC, new areas were added: for example next to the satellite settlement in the Mesarite locality (Панайотова/Баралис 2018).

Having in mind the new trends in the Early Hellenistic period, a few unusual burial structures should be mentioned, unfortunately, most of them already plundered and at least partially destroyed when discovered. The use of the 'non-normative' necropolis on the Kolokita promontory continues with two structures that have been interpreted as tombs (Кацарова 2007; Кацарова/Стоянова 2009; Миков 2007; Миков/Стоянова 2010); the associated materials provide a chronology in the first quarter of the 3rd cent. BC (Миков 2007, 344; вж. Кацарова, Стоянова 2009, Табл. XII). Monumental family tombs appear elsewhere as well, at places that are relatively far from the main necropolis and could be related to individual farms or estates. To this group belongs the tomb in the Mapite locality in the bay of Kavatsite, dated to the same period (Seure 1924, 335 f.). In 2016, another such structure was investigated closer to Apollonia, on a hill above the necropolis in the Budzhaka locality. It was used during the very end of the 4th and the first quarter of the 3rd cent. BC and one of the associated graves yielded golden jewellery from the Early Hellenistic period (Богданова et al. 2017c, 257–260) for the first time in Apollonia.

These unusual burials belong chronologically to the reign of Lysimachus and could hint at changes in the land use and the emergence of new wealthy families. It is possible to search for parallels in other western Pontic poleis, such as Odessos and Kallatis, where Early Hellenistic barrel-vaulted tombs have been investigated. Due to the specific architectural type and the clear evidence from the sources about Macedonian activity in the area, they could be related to the actual presence of noble Macedonians, for example officers from the garrison (Damyanov 2010, 272–274; 2012, 59–61; Ştefan/Sirbu 2016, 217–219). At present, the evidence from Apollonia is more difficult to interpret.

Another burial from the same period, discovered recently in the closer hinterland of Apollonia, appears to be more important: a dismantled tomb under a tumulus near the town of Primorsko, several kilometres in the interior along the course of the Ropotamo, to the south of the river, yielded a set of gold ornaments for a horse harness (Балабанов/Пантов 2017; Balabanov/Pantov 2018). It belongs to a very uniform group of such sets from Thrace, dated to the first half (mostly the second quarter) of the 3rd cent. BC (Tonkova 2010). At present, the tumulus in the Silihlyar locality is the first clearer archaeological testimony about the presence of Thracian aristocracy in the surroundings of Apollonia. It also raises the question about the borders of the Apollonian territory. As stated above, the settlement on Urdoviza peninsula (in modern Kiten) was founded already in the Archaic period and should have been dependent on Apollonia; it was suggested that it could have been an isolated 'enclave' (an *emporion*?) and was not part of the near *chora* of the polis. The available evidence indicates it existed at least to the late 4th or early 3rd cent. BC. The presence of a noble Thracian family along the lower reaches of the

Ropotamo additionally modifies the picture, at least for the Early Hellenistic period, the time of Lysimachus and immediately after it, but possibly also earlier. Even if the settlement on the Urdoviza peninsula still existed as a satellite of Apollonia, the Apollonian presence was probably limited to a narrow coastal strip.

Probably, to the same period belongs a looted and partially destroyed barrel-vaulted tomb near the village of Brodilovo, some 20km to the south and several kilometres away from the coast (Arpe/Дичев 2009). For the moment, this aristocratic burial does not have a clear context, but offers a glimpse to certain developments in the Early Hellenistic period.

The situation in Apollonia's surroundings changed visibly around the middle of the 3rd cent. BC, when a series of negative developments could be observed. The most obvious among them is the contraction of the necropolis of the city. Archaeological data indicate that the large necropolis in the Kalfata and Budzhaka localities was abandoned at about that time (Hermary et al. 2010, 51–81; Baralis et al. 2013, 322; 2016, 160–164). The chronology of the process is not completely elucidated, but the latest materials could hardly be dated considerably after 250 BC (see Damyanov forthcoming); the use of the necropolis in this period is supported by the discovery of coins of Antioch II (261–246 BC) in graves in the Kalfata locality (Герасимов 1963, 339, No. 1253–1254; see Юрукова 1982 and last in Paunov 2015, 271). From the second half of the century, Apollonians buried their dead closer to the city, mainly on the isthmus that connected it to the mainland (present-day Sea Garden park) (see Венедиков et al. 1963, 60–64, 343).

Contemporary changes have been registered at other archaeological sites in the immediate surroundings of Apollonia. At the same time at latest, the buildings in Mesarite and St. Marina localities were also demolished and abandoned (Baralis et al. 2011, 222–227; Baralis/Panayotova 2015, 982–999; Baralis et al. 2016, 168–177). The site at Mesarite could indicate a gradual development of the crisis, as some of the later graves appear to be dug in the ruins of buildings (Baralis et al. 2016, 174 f.; Панайотова/Баралис 2018). However, they could hardly date from after the mid-3rd cent. BC.

Some scholars relate the collapse of the Apollonian territory and necropolis to the troubled period of the struggles between Seleucids and Ptolemies (Гюзелев et al. 2012, 250). Others tend to see not a single conflict, but a lasting uncertainty that forced the city to abandon its surroundings; the reasons for it remain unclear (Baralis et al. 2016, 176 f.).

The activity of Antioch II in the area is attested both by his coins (considerably more numerous in the Thracian interior, Юрукова 1982; Paunov 2015, 271) and a badly damaged and extensively discussed decree (IGBulg. I^2, 388) that was found in Apollonia but probably originates from Mesambria, as indicated by the Doric dialect. The name of Antioch (II) is plausibly reconstructed and the wording suggests military help (for Apollonia and Mesambria?) rendered by a general of the Hellenistic ruler. Traditionally, the Celts have been identified as the enemies of the Greek cities (and Antioch) (Михайлов 1948, 63–66; IGBulg. I^2, 388). However, the Celts were not the only factor in Thrace in the second and the third quarter of the 3rd cent. BC (Delev 2003, 107–115; 2015, 60–63) and such a reconstruction remains hypothetical (Emilov 2005, 327–329). The presence of Thracian dynasts could be presumed in the hinterland of Burgas Bay, and one example could be Sadalas from the famous Mesambrian decree (IGBulg. I^2, 307; see IGBulg. V, 5086), for which a wide range of dates has been proposed, including later than the time immediately before the arrival of the Celts. Another inscription from the region is usually dated to the first half of the 3rd cent. BC: a decree (IGBulg. I^2, 389) that mentions the Thracian king Kotys who sent (to Apollonia?) his son Rhaiskouporis as a warrant/hostage; lately, however, a considerably later date has been suggested (Манов 2015).

The campaign of Antioch II in Thrace, respectively his presence on the western Pontic coast, is dated to shortly before the middle of the 3rd cent. BC, most often to 255–253 BC (Delev 2015, 61; Paunov 2015, 271). Based on the scarce narrative sources and scattered epigraphic monuments, A. Avram (Avram 2003b) has drawn an ambitious reconstruction of the events along the Black Sea coast in the 250s BC (including the war for the '*emporion* Tomis'), which he sets in the context

of a conflict between Antioch II and Ptolemy II. Avram envisions a large alliance of the West Pontic cities from Istros to Apollonia in support of the Seleucid, and a swift reaction against it on the part of Ptolemy II, as early as 254 BC (see Archibald 2007, 253 f., 258 f., 262). Besides, following an early hypothesis of the late Y. G. Vinogradov, Avram presumes that the actions of the general of Antioch in IGBulg. I² 388 could have been directed against the Astai (see Oppermann 2004, 145 f.). Last, in his opinion, 254 BC marked the beginning of a 'remarkable domination of Ptolemy II Philadelphus in the Black Sea', although Antioch II probably preserved his positions in the interior of south-eastern Thrace until the conquests of Ptolemy III (Avram 2003b, 1209–1211).

It is probably not by accident that the decline and the crisis in Apollonia in the second quarter and the middle of the 3rd cent. BC coincided with the rise of Dorian Mesambria that apparently emerged stronger from the period of Lysimachus' reign. The distribution of the recently identified Mesambrian amphorae is dated precisely to the second quarter of the century. They are attested at many sites in the Black Sea area, but also in the Thracian interior, and indicate an economic prosperity of the polis (Stoyanov 2011; 2016) that continued in the second half of the 3rd cent. BC (Stoyanov 2011, 199 f., n. 36). In this period, Mesambria issued gold and heavy silver coinage (Karayotov 1994, 60–62, 67 f.; 2007, 139–142). Rich burials with golden jewellery appeared already in the first half of the 3rd cent. BC and became particularly numerous in the necropolis of Mesambria in the late 3rd and the first half of the 2nd cent. BC (Kiyashkina et al. 2012, Nos. 63–73; Tonkova 1997, 87–91; 2007, 284–289). All evidence speaks of a modified balance in the region of Burgas Bay, with Mesambria becoming the leading power.

Later Hellenistic Period

The evidence about the development of Apollonia and its surroundings after the crisis in the middle of the 3rd cent. BC is insufficient. Meanwhile, at a certain point in the penultimate decade of the century the Celtic kingdom of Tylis, the influence of which is hard to detect around Burgas Bay and along the southern Black Sea coast, was destroyed by the Thracians (Polyb. 4, 46, 2). In 179 BC, the Bastarnae that were called in by Philip V of Macedonia passed (twice) near Apollonia and Mesambria (Liv. 40, 58, 8) and could have caused troubles, but more likely near the Balkan passes (Oppermann 2004, 231 f.).

Despite the decline, Apollonia managed to preserve at least partially its territory. Anchialo remained under its control to a certain moment in the first half of the 2nd cent. BC, as revealed by the well-known decree honouring the Istrian admiral Hegesagoras (ISM I, 64 = IGBulg. I², 388 bis), relating about a military conflict with Mesambria. Initially, Mesambrians took the *phrourion* ('fort') of Anchialo, but were expelled by the joint forces of Apollonians and Istrians. Eventually, the fort was razed and abandoned (see last in Bounegru 2007). With this episode, the Dorian polis imposed its complete domination over Burgas Bay. A series of funerary reliefs from Apollonia date from the same period. The deceased have been honoured by the polis and in some cases were depicted as warriors; probably, they were citizens that fell for Apollonia, another testimony for the troubled period (Petrova 2005).

The adjacent territory up to Atiya/Antheia to the north, together with the mines of Rosen ore field, most probably remained under the control of Apollonia. A 'large settlement of metalworkers' dated to 2nd and 1st cent. BC is mentioned at some distance to the southwest of Atiya (Черных 1978, 20). Hellenistic materials are known from the site in Vromos Bay (Девлова 2014, 52–57) and the Chervenka peninsula (Христов 2017a, 28–50), indicating that the network of settlements in the Apollonian territory continued to exist. Probably, it was this part of the *chora* that Hegesagoras helped safeguard.

The higher parts of Medni Rid were also inhabited in the Hellenistic period. Traces of occupation have been detected at Malkoto Kale. There, the last phase is dated to the period from the late 4th and early 3rd cent. BC to the middle of the 2nd cent. BC, with an artificial levelling of the terrain that separates it from the previous phase (Делев et al. 1982, 369–374; Gyuzelev 2008, 108 f.). A tumulus that was excavated nearby dates from the second half of the 3rd cent. BC (Делев et al. 1982, 374–377).

Having in mind the changes around Apollonia in the Hellenistic period, it is difficult to say whether it belonged to the *chora* of the polis in that period. A revival and reconstruction of the fortifications is dated to the Late Hellenistic period, in the second half of the 2nd cent. BC, when the overall situation in the region changed (see below).

The development of the region to the south is even less clear. A Mesambrian decree for an Astean aristocrat (IGBulg. I², 312) is dated to the 2nd cent. BC. Traditionally, the territories of the Astai are located in the coastal area of south-eastern Thrace, between the northern shores of Propontis and the region of Apollonia (Str. 7, 6, 2; 7, 6, fr. 47; Plin. N.H. 4, 45; Ptol. Geogr. 3, 11, 6; Ps.-Skymnos 728–229; see Делев 2010, 101 f.). The Mesambrian inscription attests their presence in the northern part of this area. The Astai appear in the sources in the early 2nd cent. BC (Liv. 38, 40, 6–15), if one rejects the hypothesis that they were the enemies of Antioch II in the above-discussed Mesambrian (?) decree IGBulg. I² 388.

In the last decades of the 2nd cent. BC, silver and bronze coins of king Mostis appeared in the same area. Based on his tetradrachms, it is known that his rule lasted at least 38 years, but its chronology remains controversial. Based on his presumed ties with Mithridates VI Eupator, on parallels in the iconography of his coins with issues of Bithynia and Cappadocia, and on epigraphic evidence, the end of his reign is usually dated to 86 BC (Юрукова 1992, 165–172), ca. 90 BC (Карайотов 2000, 63) or to 89–88 BC (Лозанов 2017, 20). Lately, a slightly earlier period has been suggested, with a lower limit of about 97–95 BC (Yordanov/Agre 2016, 182) or even ca. 100 BC (Paunov 2014, 458, 467–469; see De Callataÿ 2016, 364–366). However, the latter date is dependent on the identification of Mostis as a ruler of the Kainoi (Loukopoulou 1987, 81, n. 97; Sayar 1992, 191), which kingdom was conquered by the Romans in 101/100 BC (see Paunov 2014, 469; Delev 2015, 70; Lozanov 2015, 76).

Based on the distribution of Mostis' coins and two inscriptions from Bisanthe and Heraion Teichos (Loukopoulou 1987, 80 f.; Sayar 1992), the territory under his control has been defined from Byzantion and Bisanthe to the south up to Apollonia and Mesambria to the north, with a core probably in the southern part (Карайотов 2000, 63; Paunov 2014, 458, 469 f.), hence the connection with the Kainoi. Nonetheless, taking into account the accumulation of numerous finds of coins in a clear archaeological context in the northern parts of the above-defined territory (see below), it seems more probable to identify Mostis as an Astean ruler (Лозанов 2017, 20; see also Delev 2015, 69). This assumption eliminates the need to limit his reign to the conquests of Titus Didius.

During the last few years, several sites have been investigated to the south of Apollonia that added more substance to Mostis and shed light on the history of the region in the Late Hellenistic period. In Farmakida locality near modern Primorsko, not far from the Early Hellenistic tumulus of Silihlyar and next to a crossing of the Ropotamo, a fort was investigated and dated from the late 2nd cent. to the middle of the 1st cent. BC. It is a rectangular fortified space with a single tower and a single residential building in the interior (Hristov/Pantov 2016, 33–43; Христов/Пантов 2017). The site, interpreted as *tyrsis* by the excavators, could hardly be assigned to the territory of Apollonia, despite the fact that the proximity to the city is reflected in the numismatic material, as eleven bronze coins of Apollonia were found. However, they are less numerous compared to the coins of Mostis (21) (Hristov/Pantov 2016, 119–143).

The situation is complemented by two Late Hellenistic graves, one with a full set of weapons, dug into an earlier mound, also near Primorsko but closer to the shore (Балабанов 2014). At the present state of research, it is not possible to trace any continuity between the Thracian presence in the region during the Early Hellenistic period (the tumulus in the Silihlyar locality) and the evidence from the 2nd and 1st cent. BC. Nonetheless, it could be claimed that the territory of Apollonia in the Hellenistic period, at least after the death of Lysimachus, probably did not reach beyond the river of Ropotamo.

Two more sites still more to the south add to the picture. One is a fortified site overlooking the mouth of the river Veleka near modern Sinemorets, dated to the period from the middle of the 2nd to the early 1st cent. BC (Agre 2016, 208; Агре/Дичев 2017). Part of the wall with a tower

has been uncovered (Agre 2016, 11–38). This site again has been identified as a ruler's residence, but a more modest interpretation as a border fort has been suggested (De Callataÿ 2016, 366). Nearby, a tumulus with a rich female burial has been investigated, dated to the late 3rd or (rather) early 2nd cent. BC (Arpe 2007, 77 f.; Agre 2009; Arpe 2013; Agre 2016, 211). It seems to support the former interpretation, but one should have in mind the slightly different chronology. While the tumulus illustrates the presence of Thracian aristocracy in the area at the turn of the 2nd cent. BC, the hoard of silver coins that was discovered at the fortified site points to a direct connection with Mostis: out of 199 tetradrachms, 36 are his (Yordanov/Agre 2016). The bronze coins of the king are also the most numerous (Koychev 2016, 193–200). The chronology and the coins provided grounds for considering the site a residence of a Thracian nobleman, a governor in Mostis' state (Agre 2016, 212). The hiding of the treasure is related to the Roman expansion in Kainika in 101/100 BC.

The third contemporary site is located in the interior, along the course of the Veleka near the village of Brodilovo, and is again a fortified place with a tower (Дичев 2014; 2016; 2017). There are again coins of Mostis and the functioning of the site is dated to the period from the last quarter of the 2nd to the first quarter of the 1st cent. BC. It was probably destroyed in the late 70s BC.

These three sites create a rather uniform picture of the late 2nd cent. BC, when the coastal region to the south of the Ropotamo was undoubtedly under Thracian control, the name of Mostis being very prominent. His coins have also been discovered to the north, around Apollonia and Mesambria. The available evidence indicates that his rule was implemented by means of a network of fortified sites at strategic locations. The excavators interpret them as residences of aristocrats or governors, but it is equally possible that they were forts with garrisons that controlled the exploitation and the traffic of resources in the region (Лозанов 2017, 18–20, 45). The chronology of the sites is very similar and clearly indicates changes in the last decades of the 2nd cent. BC, the time of Mostis. Nonetheless, a certain retrospection is also possible due to the slightly earlier burial mound at Sinemorets and the Early Hellenistic tumulus in Silihlyar locality near Primorsko.

These observations raise one more time the question about the 'large' territory of Apollonia, reconstructed based on the information of Strabo (7, 6, 1) and Pseudo-Skymnos (728–730) as reaching as far to the south as Thynias. Certainly, such a hypothesis seems implausible for much of the Hellenistic period, at least after the middle of the 3rd cent. BC, judging by the clear signs of a crisis in Apollonia. The information about the coastal settlements is very sparse. The available evidence from Urdoviza, however meagre, is quite positive for the time from the 6th to the late 4th and early 3rd cent. BC, but then seems to discontinue. Still more unclear is the picture of the ancient settlement under modern Ahtopol (Aulaioteichos?), far to the south, near Sinemorets and Brodilovo. The overall analysis of the region again places it within the kingdom of Mostis in the late 2nd cent. BC, possibly as an administrative centre (Лозанов 2017, 38, 45). Against this background, it appears quite probable that the network of Apollonian *emporia* presumed for the earlier period did fall apart under the new historical circumstances.

In the early 1st cent. BC, the entire western Pontic coast, including Apollonia, came under the influence of Mithridates VI Eupator, who won over 'the Greeks around the Black Sea and the barbarian people beyond them' (App. Mithr. 15) (see Oppermann 2004, 233 f.). The clearest testimony for the relations between Apollonia and the Pontic ruler is provided by a decree for a general of Mithridates, discovered on the island of St. Kirik; the general was in command of troops that were sent due to a military alliance (*symmachia*) (IGBulg. I^2, 392). The date of the alliance remains unclear, but the establishing of Mithridates' domination over the western Black Sea area is usually dated to the first decade of the 1st cent. BC, before the First Mithridatic War (Gaggero 1978, 296; Avram/Bounegru 1997, 156).

In this context, it is important that Mostis has been identified as an ally of Rome and not of Mithridates VI (Delev 2015, 69; Лозанов 2017, 20). The fortified sites at Brodilovo, Sinemorets, and Farmakida, as well as the distribution of the coins of the Thracian ruler, suggest an expansion

to the north that probably threatened the Greek *poleis*. It could explain the alliance between Apollonia and Mithridates VI, a famous champion of the Greeks against the neighbouring 'barbarians' (Gaggero 1978, 296–298). Possibly, some of the above-discussed sites could have been targeted by Mithridates' campaign in the region in 89/88 BC (Лозанов 2017, 19).

The details of the alliance between Apollonia and Mithridates VI remain unclear. Nothing suggests the city regained its importance after the crisis in the 3rd/2nd cent. BC; it is probably not by accident that of all major West Pontic poleis only Apollonia did not mint heavy coinage in the period of the Mithridatic Wars (see De Callataÿ 1997). On the other hand, there is an explicit epigraphic testimony to the military alliance with the Pontic king. It could be that some special relations with Mithridates predetermined the sack of Apollonia during the campaign of the proconsul of Macedonia Marcus Lucullus in 72/71 BC (Eutrop. Brev. 6, 10), when the Romans carried away the colossal statue of Apollo (Plin. N.H. 34, 18). Apparently, the other West Pontic *poleis* had better fate (see Lozanov 2015, 77); neighbouring Mesambria has yielded a decree honouring an officer of Lucullus (IGBulg. I^2, 314a), indicating some kind of agreement.

In the middle of the century, another calamity could have befallen Apollonia, which was the southernmost West Pontic city to have suffered from the campaign of the Getic ruler Burebista (Dio Chr. 36, 4; see Nawotka 1997, 48–54). A Mesambrian inscription explicitly mentions a conflict with Burebista (IGBulg. I^2, 323).

Roman Period

Before the creation of the Roman province of Thrace, Apollonia maintained relations with the rulers of the 'client' Thracian kingdom of Bizye, and the city was given as a reference point for Ptolemy's strategy of Astika, which was located in the coastal region from the city of Perinthos to Apollonia (Ptol. 3, 11, 6). Several inscriptions shed some light on the situation in the area. The decree about Rhaiskouporis, son of King Kotys, sent as a hostage to the city at a certain moment in the second half of the 1st cent. BC has been re-dated to this period (IGBulg. I^2, 389; see Манов 2015).

Another monument (IGBulg. I^2, 399) is a dedication to Apollo Ietros for the good health and safety of Rhoimetalkes II and Pythodoris II (after AD 19); the monument attests the functioning of Apollonia's main sanctuary after the sack in 72/71 BC. Particularly active in the region of Burgas Bay was Apollonios, son of Eptaikenthos, strategos of Rhoimetalkes II, who resided in Anchialo: dedications by him are known from Anchialo and the sanctuary at Aquae Calidae. Recently, a dedication to Zeus Patroos by his wife Leonto, found in Apollonia (IGBulg. I^2, 402), was complemented with another find from the city: a base with a dedication to Zeus Progonikos by Tiberius Claudius Proclus, son of Rhoimetalkes, identified as grandson of Apollonios. The inscriptions reveal the existence of a sanctuary of Zeus in Apollonia and suggest the family had Apollonian roots (Шаранков 2015, 64–68).

The presence of important Thracian families in Apollonia is confirmed by another inscription, dated to the 1st or 2nd cent. AD (IGBulg. I^2, 400). It praises Metokos, son of Taroulas, as *ktistes* ('founder') of the city after an unknown disaster; he also constructed a *tripylon* and another unclear monumental structure for Apollo Ietros. Due to chronology, it is not possible to relate these works in Apollonia to Lucullus' sack of the city.

It appears that the city enjoyed stable and close ties with the Thracian kingdom and depended on the generosity of wealthy local aristocracy, a situation that differs greatly from the Classical or even earlier Hellenistic times and reveals the general changes in the overall historical picture and the modest resources of Apollonia.

Political developments in the region kept Apollonia apart from the other western Pontic poleis. With the establishment of direct Roman rule to the north of the Balkan range, the cities from Istros in the north to Mesambria in the south were organised in the *praefectura orae maritimae* (*ripae Thraciae*) under the governor of Macedonia and were later added to the province of Moesia (Nawotka 1997, 58 f., 77; Lozanov 2015, 81). Apollonia remained in the territory of the Thracian

Kingdom until it was abolished and became part of the province of Thrace. Therefore, the city was left out of the Pontic *koinon* in the 2nd and 3rd cent. AD (Nawotka 1997, 216–221). The importance of Apollonia should have declined even more with the foundation of the Roman colony of Deultum at the head of the navigable Mandrensko lake in the 70s AD; the territory of the new city practically surrounded Apollonia and whatever land possessions it was left with (Балабанов/Петрова 2002, 238 f.; Delev 2009, 247).

Archaeology is unable to add significantly to the picture. The discovery of two votive tablets of the Thracian Horseman on the island of St. Kirik (Панайотова et al. 2010, 297) suggests the introduction of new cults in the city, in addition to the epigraphic evidence of the worship of Apollo Ietros and Zeus, and indicate the sacred precinct was still in use. Archaeological investigations have revealed traces of Roman habitation in the central part of the peninsula of Sozopol's old town, but the excavations in the southern periphery could indicate a shrinking of the occupied area (Baralis et al. 2013, 318), consistent with the presumed decline of Apollonia.

The isthmus to the mainland and the lower slope opposite the city continued to be used as the main necropolis in the Roman period, with burial practices that indicate continuity from the Hellenistic period. Cremations, mainly in situ, are more numerous than in earlier times, and pits, tile and cist graves have been investigated (Цанева/Панайотова 1991).

Burials from the Roman period have been detected also farther away from the city, probably related to land ownership. Two cremation graves from the 1st cent. AD were discovered in the higher parts of the Budzhaka locality, next to an Early Hellenistic family tomb (Богданова et al. 2017c, 259). Burials from the 2nd cent. AD are also reported from the area of the Kolokita promontory (Лазаров 1972). In both cases, it is not possible to trace a clear continuity with finds from the previous periods.

Based on the available evidence and the unclear administrative status of Apollonia, it is impossible to say what remained from the territory of the city in the Roman period. It may be presumed that at least some of the coastal settlements from the previous periods continued to exist. For example, traces from habitation have been detected in Vromos Bay (Христов 2014a; 2014b).

More significant changes occurred with the Christianisation of the Roman Empire. A mention in Eusebius of Aelius Publius Julius, bishop of Debeltum, indicates that the new religion was spreading in the region already in the 2nd cent. AD (Euseb., Hist. eccl. 5, 19, 3). In the 4th cent. AD, the establishment of Christianity as official religion of the empire brought a change in the name of Apollonia. The pagan pedigree was renounced, and the city was renamed Sozopolis, 'City of Salvation' (Anonym., Peripl. Ponti Eux. 84–87).

Summary

In the late 7th cent. BC, settlers from Miletos in Ionia settled on an offshore island and a peninsula at the south-eastern end of present-day Burgas Bay and founded Apollonia Pontica (Sozopol in Bulgaria). The site did no command extensive agricultural resources, but had an excellent harbour and offered access to the metal riches of Medni Rid. The Greeks most probably found a settled Thracian population in the hills and appear to have formed quickly peaceful relations with them. Within the first generation of colonists, Apollonians were already exploiting the copper mines, which probably served as a basis for the steady and upward development of the city in Archaic and Classical times. Stone architecture appeared in the temenos in late 6th cent. BC, followed by the famous bronze colossus of Apollo several decades later. There is evidence of a population surge and changes in the city in the middle and the second half of the 5th cent. BC. Apollonia controlled some arable land in the coastal plain, up to Atiya in the north, and already in the first half of the 6th cent. BC started to found satellite settlements, some as far away as 20 to 25km. There is ample evidence of trade with the Thracian interior, via the navigable estuaries of Burgas Bay. This prosperity continued at least to the mid-4th cent. BC, when the campaigns of Philip II and the collapse of the Odrysian kingdom disrupted the balance in the area. During the first

half of the 3rd cent. BC, Apollonia emerged from Macedonian domination in a visible decline, while Mesambria was gaining strength to the north of Burgas Bay. A major crisis is attested archaeologically around the middle of the century. In the following centuries, Apollonia gradually lost its importance, while archaeological and epigraphic data reveal interactions with the local Thracian rulers. Another major blow was the sack by Marcus Lucullus in 72 BC and, after the creation of the Roman province of Thrace, Apollonia was totally obscured by the new Roman cities.

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II. Investigations in the Rosen (Medni Rid), Zidarovo and Varli Bryag Ore Fields

Tim Rödel

Geology of the Region

Keywords: geology, geoarchaeology, prehistoric, Medni Rid, supergene, copper, minerals

Geological Framework of the Medni Rid Area

The geology underlying the survey area of the Medni Rid mountain chain south of Burgas and about 6km west of Sozopol was shaped by the continental collisions of crustal fragments and oceanic lithosphere during the alpine orogenesis (Cvetkovic et al. 2016; Schmid et al. 2008). Moreover, the study area is a systematic component of the Sredna Gora (or Srednogorie) unit of the south-eastern Europe segment of the large-scale Alpine-Himalayan collisional orogenic belt and part of the Dacia Mega unit, positioned between the Moesian Platform and the Rhodopes including Strandzha. Additionally, it represents the easternmost extension of an L-shaped structure called the Apuseni-Banat-Timok-Srednogorie (ABTS) belt (*fig. 1*) reaching from Romania and Serbia to Bulgaria (Heinrich/Neubauer 2002; von Quadt et al. 2005) including sites like Rudna Glava or several active mines like Majdanpek and Bor (Serbia) or Chelopech in Bulgaria (Kamenov et al. 2007; Ciobanu et al. 2002). Deposit types are divers including skarn, porphyry, massive sulphide, vein, stratabound and carbonate replacement deposits. This metallogenetic volcanic belt is roughly 30 to 70km wide and has a length of more than 1000km. Although the most prominent and largest deposits are located in the western and central part of the Srednogorie unit, some small but rich vein deposits have been mined on the Black Sea area of the easternmost extension of the geological unit.

Predominant rock types in the study area south of Burgas are high-K, calc-alkaline but also tholeiitic Late Cretaceous lavas, minor pyroclastics and igneous intrusions (Georgiev et al. 2012) with magmatic activity peaking between 78 to 81 million years. More exotic rocks like the high-K, mafic Ankaramites rich in phenocrysts of olivine and clinopyroxene are present in the area (Georgiev et al. 2009). The geological evolution of the Burgas area was interpreted based on crystallisation ages as an arc magmatism during a southwards retreating oceanic crust and extensional rifting with associated igneous processes. Magmatism started at 95-90Ma in the northernmost East Balkan region shifting to the south, with the most juvenile intrusion of 78Ma in the Strandzha region (Georgiev et al. 2012). Mesothermal copper-molybdenum, copper-gold and gold-lead+zinc+copper vein-type mineralisations at Rosen, Varli Bryag and Zidarovo (Berza et al. 1998) formed in consequence to the shallow magmatic processes in the area. A total deposit size of 10Mt was estimated for each of the deposits by Ciobanu et al. (2002) based on the work of Milev et al. (1996). For a comprehensive overview of the ore geology of the area refer to Попов et al. (1993) in Bulgarian language.

Overview on the Geological Field Work

Although the main deposits throughout Medni Rid and the surrounding territory have been explored and mined extensively, especially during communist times (Bonev et al. 2006), there are plenty mineralogical traces giving insight into the ore composition. This is useful for reconstructing the texture, structure and style of mineralisation that could have been utilised in mining activities prior to modern exploitation of the deposits. On site, investigations are necessary in ground truthing finds from remote sensing data provided by LiDAR scan. A systematic prospection of archaeometallurgical areas of interest and general geological reconnaissance was undertaken.



Fig. 1. Schematic position of the ABTS metallogenetic belt in context to geological regions with the Burgas area marked (after Georgiev et al. 2012, Fig. 1 A).

Most prominent traces of recent mining activities are the mining and transportation shafts at Rosen or Propadnala Voda. Whereas large tonnages of material have been removed with industrialised processes, only traces of the actual ore can be found today. When characterising the found material, the time of exposure has to be considered as meteoric weathering can affect the composition by alteration (e.g. hydratisation of minerals) or remobilisation of elements. This may have happened naturally to the exposed deposits on the surface or after the metallurgical use and extraction of the material. Traditional geological field methods were used to identify ore minerals, predominant gangue minerals and textural patterns with hand lens and bare eye. The field methods were exemplary supported by microscopy on a selection of samples using transmitted and reflected light. Oil immersion was used on high-grade ore samples for optimal reflectance colours. Both x-ray powder diffraction (XRD) and scanning electron microscopy with coupled energy dispersive x-ray analysis (SEM-EDX) was applied to a couple of selected samples. The relative hardness of the ore and the wall rock was distinguished with a knife whereas the calcium carbonate content has been estimated on the basis of the intensity of the reaction with hydrochloric acid. The wall rock alteration was exemplary classified using portable reflectance Vis-NIR-SWIR spectrometer TerraSpec. The description of the geological structure of the mined-out vein deposits and the wall rock texture with its distinct alteration features gives insight on the processes leading to the formation of the ore body, its shape and further its accessibility for an exploitability by men. Structural data has been extracted in the field by the use of a geological compass to gather information on strike and dip direction and the corresponding angle. Due to accessibility and safety reasons, only surficial exposed geological features could be explored. For that, an in-depth insight of the ore mineralisation or mining activities was not viable and an interpretation is difficult. Surficial traces of underground mining are challenging when interpreting their origin. Aggravatingly sinkholes from shafts and edits can easily be mistaken for mining pits, especially in areas with high vegetation and soil cover. It was, therefore, important to gather information from small opencast mining or exploration trenches and pits. Targeting these areas by the use of LiDAR images was essential. The results presented in the following are based on observations made in field surveys in April 2015 and 2016 respectively. Whereas a generalised overview is presented here a more detailed classification of the mineralised districts would require profound work on specific sites in the field and a combination of different analytical techniques at the lab.

Mineralisation and Traces of Mining Activity at the Medni Rid Area

Although the material found around the mining pits or trenches generally varies in mineralogical composition, it can readily be described as a mineralisation hosted by subvertical vein-type deposits. An indication in the field is the trench-like character of the mined-out sites which redraws the original linear structure of the mineralisation cross-cutting, replacing and altering the wall rocks comprised of mafic igneous rocks or pyroclastics. Handpieces of the vein material commonly have a light grey to dark grey metallic colour originating Geology of the region 307 from massive haematite (*fig. 2*), quartz and minor calcite. The metallic grey iron oxide haematite often occurs as lamellar highly reflecting variety specularite or fine-grained massive chunks with minor wall rock.

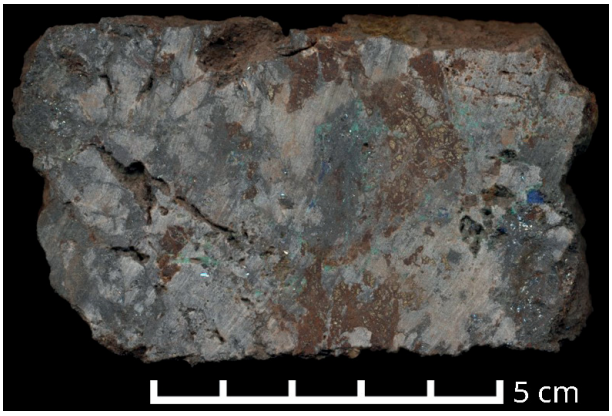

Fig. 2. Image of a cut hand specimen exhibiting typical characteristics of the Medni Rid mineralisation. It is comprised of metallic grey haematite, light grey to white quartz, red-brownish iron oxides replacing primary chalcopyrite and green to blue copper secondary minerals on cracks and coatings on the surface.

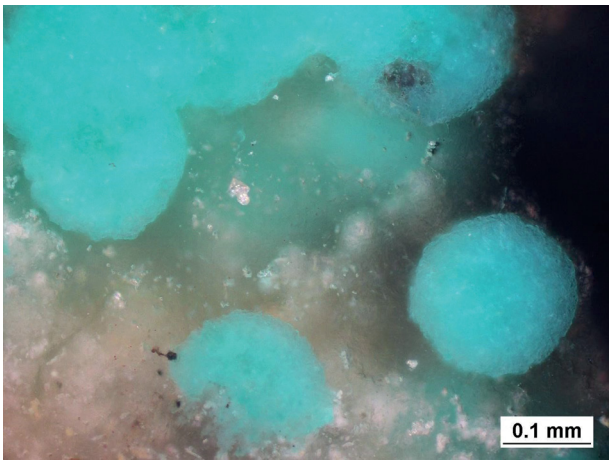

Fig. 3. Reflected light microscopic image of a thick polished section containing colloidal aggregates of pseudomalachite intergrown with copper-rich clay minerals, parallel polariser.

Quartz often occurs as translucent euhedral elongated crystals or anhedral masses. Secondary copper minerals are often found on the surface of ore specimens which exhibit the typical green-blue colours and are further described in the following sections below (*fig. 3*). Minor primary chalcopyrite can be found associated with altered copper minerals. Most remnants of copper mineralisation found in the survey area represent characteristics of weathered mineral assemblages due to the small proportions of sulphides compared to the amount of secondary copper minerals.

Mesothermal veins of the Medni Rid are characterised by varying formation temperatures between 200°C to 350°C in shallow emplacement depths of 1300m to 500m, as exemplarily shown by Tarkian/Breskovska (1995) for the Zidarovo copper polymetallic deposit. The mineralisation is often accompanied by intense silicification and hydrothermal wall rock alteration. Silicification is observed in the field as fine quartz veinlets transecting the wall rock or as fine-grained impregnation. As a consequence, the wall of the veins can be highly resistant to weathering, displaying steep, trench-like morphological features. The hydrothermal wall rock alteration can be observed in the field as prominent beige-orange or greenish crème discolourations readily distinguished from the dark grey original colour of the host rock. Moreover, the altered rocks are often brittle or soft. Discolorations, as well as changes in the mineral composition, are most likely caused hydrolytic mineral reactions transforming feldspars and mica to clay minerals or other alteration phases (Pirajno 2009).

The Medni Rid mountain range is cut by several mineralised veins roughly striking in a northeast/south-west or east/west direction. Remains of the ore veins are today identifiable by morphological features in the landscape like pits with diameters up to 10m, mining trenches up to 10m wide and 4m deep as well as heaps of non- to minor-mineralised material resulting from mining activities. Circular depressions of mining pits are a result of locally constrained exploration and mining activities underground. Mining trenches developed as a consequence of the interconnection of an interconnection of several sinkholes tracing the collapse of underground mining tunnels following the strike of the vein or result from surcifical opencast mining.

A prominent example for surficial opencast mining and modern underground activity is the site of Propadnala Voda. It is located in the central part of Medni Rid, 6km west of Sozopol. An area of 15,000m^2 is devoid of vegetation, most likely due to high soil contamination with metals from the opencast mining. An indication for the high metal content is the presence of *minuartia verna*, a plant of the family *caryophyllaceae* typically growing on soil-forming on heaps of mineralised rock material. Propadnala Voda is more exotic with

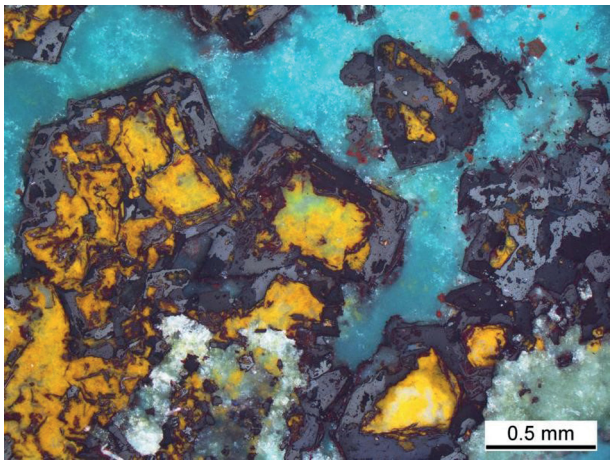

Fig. 4. Reflected light microscopic image of a thick section containing spangolite veins (blueish-green) rimmed by anisotropic haematite (light to dark grey) and limonitic clay (orange), crossed polariser.

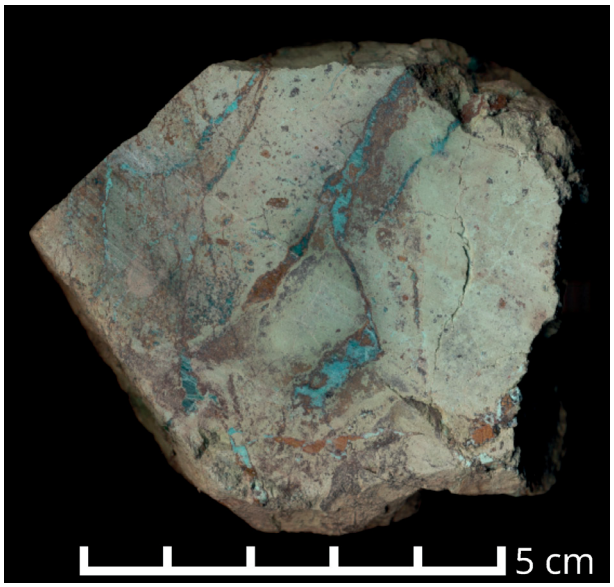

Fig. 5. Image of a cut mineralised grab sample from Propadnala Voda containing the green copper sulphate spangolite, cross-cutting the altered wall rock along veinlets rimed by haematite.

regard to its mineralogical composition compared to other mining sites of Medni Rid. Hypogene copper sulphides are absent in the material found at the surface, which indicates a cap of oxidation weathering topping the exposed portions of the vein deposit (Taylor 2011a). Fieldstones collected are grey to greyish-white or red-brown iron crusts. Noteworthy are abundant green, turquoise to azure seams and coatings frequently found on rock pieces which indicate secondary copper minerals. Vein-like structures pervading some specimens appear to be vitreous (*fig. 5*) while some cavity fillings are radial or collomorphous in shape. Optical microscopy and scanning electron microscopy (SEM) with x-ray microanalysis (EDX) as well as x-ray powder diffraction investigations depict a broad variety of mineralogical components constituting green minerals observed in the field. Reflectance spectroscopy with field spectrometer (TerraSpec) was performed on a couple of samples to determine the wall rock alteration. A simple, general classification of copper secondary minerals as malachite or azurite, both copper carbonates, is wrong even though minor accessory portions might occur.

The copper sulphate spangolite, Cu6Al(SO4)(OH)12Cl·3H2O, was identified using x-ray powder diffraction and characterised by optical microscopy (*fig. 4*, *5*). It is described as a rare secondary mineral from the oxidisation zone of hydrothermal copper deposits (Anthony et al. 2003) representing a stable oxidised environment. Microscopically it appears as anhedral, microcrystalline green vitreous vein fillings rimmed by euhedral quartz and haematite internally replaced by limonite. A distinction from the more common copper silicate chrysocolla on the basis of optical properties is difficult. The wall rock consist of clay minerals and relic quartz from veining. A proper classification of the alteration phases of the wall rock using reflectance spectroscopy would be useful determining the alteration regime of the rock material (Hauff 2008). Further below this was performed exemplary on a couple of samples.

SEM-EDX analysis was used on another sample exhibiting different macroscopic characteristics. Part greyish-green with green secondary copper minerals and partly orange, this piece represents an oxidation contact illustrating the supergene processes forming secondary copper minerals. Copper minerals are comprised of copper phosphates overgrown by copper silicates (*fig. 6*). The element analysis of the latter revealed copper concentrations between 41% and 52% and silica contents between 19% and 23%. Therefore, it is likely to be the mineral plancheite, Cu8Si8O22(OH)4·H2O, or shattuckite, Cu5Si4O12(OH)2, which can be mistaken for one another, although the green colour is more characteristic for plancheite.

Both minerals are typically associated with oxidised portions of copper deposits (Anthony et al. 1995). Accessory element concentrations of aluminium, iron, calcium or chlorine are often detected but with no satisfactory precision. The copper silicates form rounded bean-shaped aggregates made up of microcrystalline minerals or occur as radial, colloidal vein fillings rimmed by euhedral quartz. They contain irregular patches of radial, copper phosphate minerals which are easily confound with the carbonate malachite. Due to similarities in mineralogical properties the according phase is called pseudomalachite. The mineral is constituted of approx. 60% copper and approx. 10% phosphorous. Besides the copper minerals, angular grains of the iron oxide magnetite occur dominantly martitised, replaced by haematite and overgrown by limonite. Turquoise greenish copper phosphates also occur as round botryoidal aggregates (*fig. 3*) intergrown with copper-rich clay minerals or as xenomorph massive fillings in veinlets rimmed by euhedral quartz crystals.

Typical for the hand specimens taken from the site of Propadnala Voda is the intense wall rock alteration resulting in the formation of clay minerals. Reflectance spectroscopy with field spectrometer (TerraSpec, *fig. 7*) revealed typical absorption features exhibited by a mixture of montmorillonite and other smectites with minor kaolinite (Hunt/Ashley 1979; Hunt 1977). Especially deep absorption at the approx. 1415nm and approx. 2210nm band as well as a deep-water band around approx. 1910nm and an asymmetric shape are characteristic for montmorillonite (Hauff 2005). Slight shoulders at the 1415nm and 2210nm band indicate an influence of kaolinite but expressing low crystallinity which indicates surficial weathering rather than a hydrothermal formation during the emplacement of the vein deposit. In addition, the samples with elevated contents of copper silicates exhibit chrysocolla absorption features at a wavelength of 2257nm. Coexistence of kaolinites and smectites (montmorillonite) but a predominance of the latter indicate moderate to elevated (basic) pH during the alteration and low temperatures (<200°C) (Corbett/Leach 1998). Smectite portions have peak values below the water table and the redox front and typically form above mafic rocks (AusSpec International 2010).

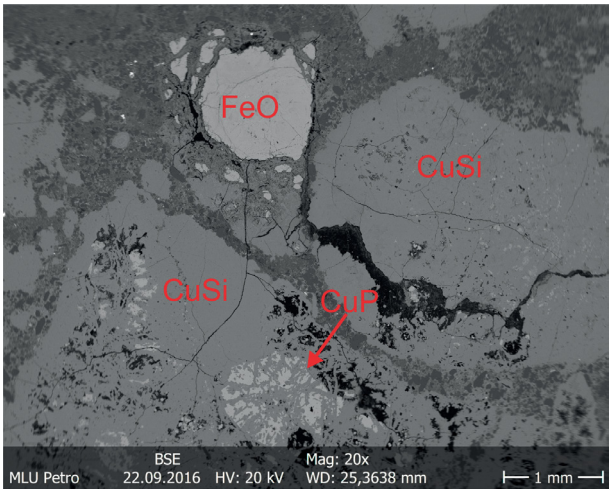

Fig. 6. SEM-BSE image showing the texture and composition of the secondary copper minerals from Propadnala Voda. The copper silicate mineral plancheite (CuSi) forms bean shape to polygonal aggregates overgrowing the irregular patchy copper phosphate pseudomalachite (CuP). Hematised magnetite (FeO) occurs as relict angular grains in the groundmass.

These conditions are not fulfilled in a hot mesothermal vein system (see above) but during surficial weathering environment, for example at an exposed site like Propadnala Voda.

As demonstrated above exemplary for the prominent mining site of Propadnala Voda, the mineralogy of the ore sites is more complex than originally thought. Therefore, a metallurgical use and processing of these silicate, sulphate and phosphate minerals has to be discussed in the context of prehistoric copper production. Eventually, a distinct mineralogical fingerprint can be taken from the deposits resulting from the weathered copper minerals. For this purpose, the secondary copper mineralogy of the known ore sites of the Medni Rid has to be investigated in more detail.

Mining Site of Varli Bryag

The mined-out vein deposit of Varli Bryag is located ca. 6km south-west of Burgas, is an impressing relic of historical mining. Although situated outside of Medni Rid it represents a vein-type mineralisation characteristic for the mesothermal mineralisation in the easternmost extension of the ABTS metallogenetic belt. Due to a lack of

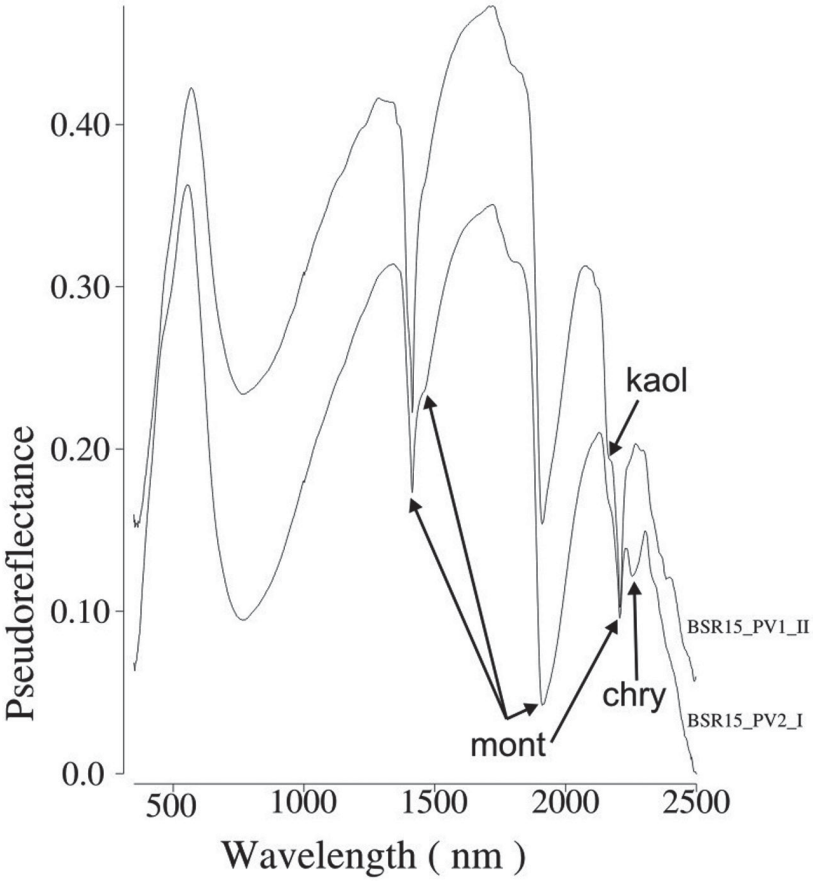

Fig. 7. Reflectance spectrum of two exemplary samples in the range of 350nm to 2500nm. Characteristic are the prominent absorption features expressed by montmorillonite (mont). Shouldering left of the 2209nm band is an indication for the kaolinite (kaol) content. Chrysocolla (chry) can be present in the spectrum, although it has not been observed microscopically.

vegetation cover and good exposure, it provides an excellent opportunity to study the mineralisation which has been used in mankind's history.

Morphologically, the remnants of the deposit form a linear series of lens-shaped mining trenches following the course of the vein up the slope of a ridge. Outcropping mined out portions are deepest at the south/south-western slope of the ridge whereas only traces occur on the northern slope, probably representing surficial exploratory ventures. Remnants of the ore vein are dipping almost subvertically between 75° to 80° in the direction of west/south-west 110° to 130°. Mining of the vein obviously occurred along with lenticular bulges. Of four mined out areas there are two larger pits of around 35m length, maximum of 6m width and two smaller ones with 10m to 15m and width of up to 5m respectively. In between these lens-shaped mining pits, only indications of vein mineralisation occur as quartz and haematite-rich assemblages. The surrounding mafic igneous wall rock is highly silicified resulting from the emplacement of a vein mineralisation. Due to this fact the walls of the mined-out vein are highly resistant to weathering processes, forming a steep boundary. Because the mining pits are blocked by larger boulders in a depth of 3m to 4m an estimation of the extension following the dip of the vein is not possible based on surficial observations. Absence of dumped material resulting from mining activities is an indication for the efficient selection of ore material from non-mineralised wall rock during mining. A schematic profile of the mineralised vein is depicted in fig. 8.

Traces of high-grade mineralisation could only be found as hand specimens at the site whereas abundant and intense quartz veining accompanied by rich haematitisation is widespread. A characteristic zonation of the veins can be observed on different scales. Minute veinlets, as well as larger individual veins, express a peripheral area comprised of haematite bordering the wall rock. The inner parts of the vein are formed of quartz, often forming euhedral prismatic crystallites in geodes.

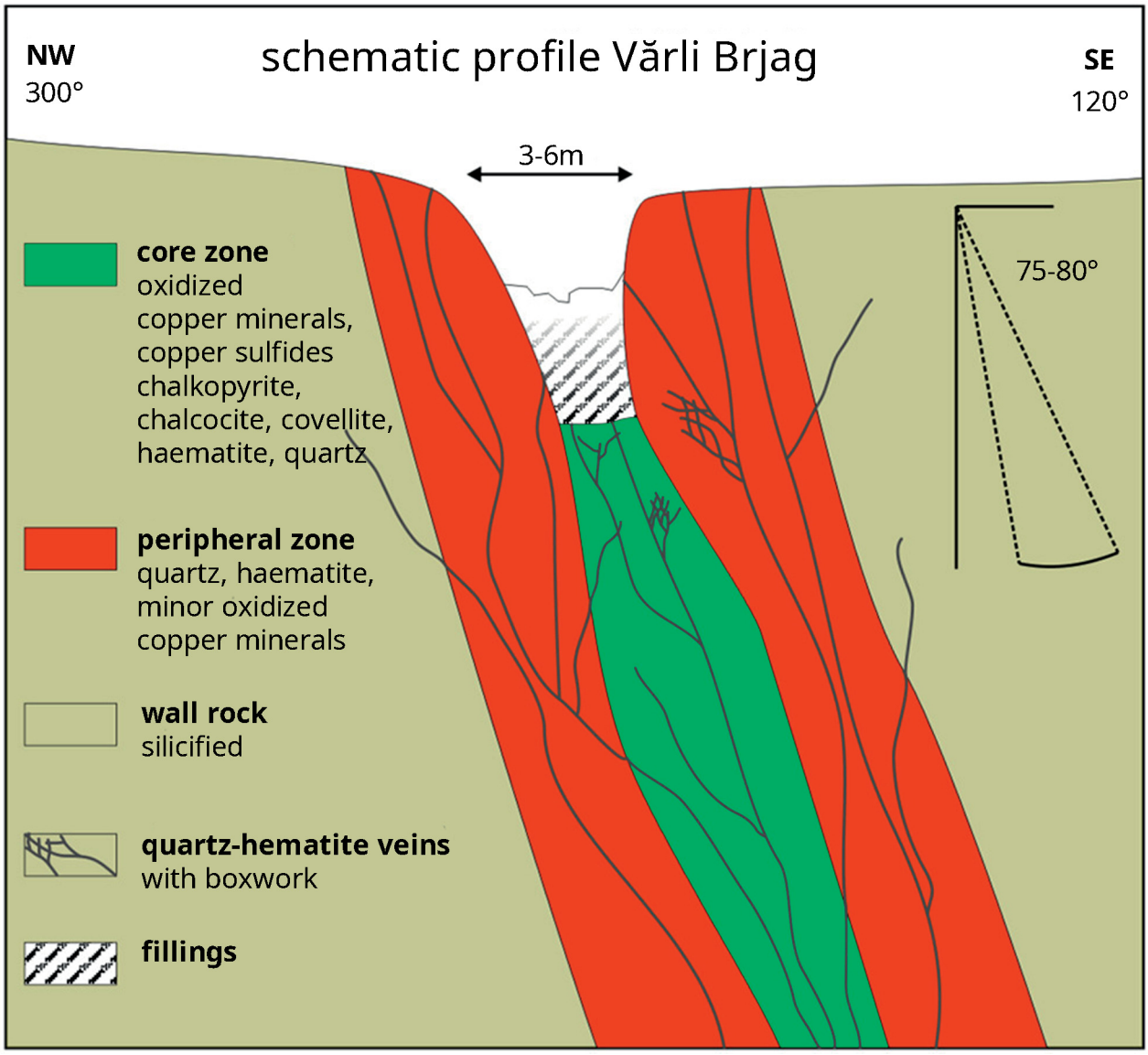

Fig. 8. Schematic profile of the Varli Bryag ore vein with structural features and the mineralised zones found as relicts at the outcrop today.

Green to turquoise coatings of secondary copper minerals often occur along the contact surface between mined-out vein material and the wall rock, along fine seams or even as colloidal coating overgrowing euhedral quartz crystals in geodes. Only the today mined-out core zone of the Varli Bryag ore vein hosted significant copper contents. Relicts of the primary sulphide mineralisation are present also as boxwork textures (Taylor 2011b). Fine quartz or amorphous silicate permeate a completely corroded mixture of iron oxides and clay minerals resulting in a net-like system of veins and cavities. Primary sulphides were altered during weathering resulting in dissolution and re-precipitation locally or in the distance to the deposit (Reich/Vasconcelos 2015; Sillitoe 2005).

A high-grade copper hand specimen from the Varli Bryag mining site will further be used to depict characteristics of the mineralisation exploited here. It is a mixture of primary chalcopyrite, secondary chalcocite and covellite as well as secondary malachite. The wall rock is replaced by abundant quartz, euhedral prismatic epidote, chlorite and sericite (*fig. 9*). Macroscopically this alteration suite is identified by its greenish colour. Specular haematite occurs as euhedral crystals and partly

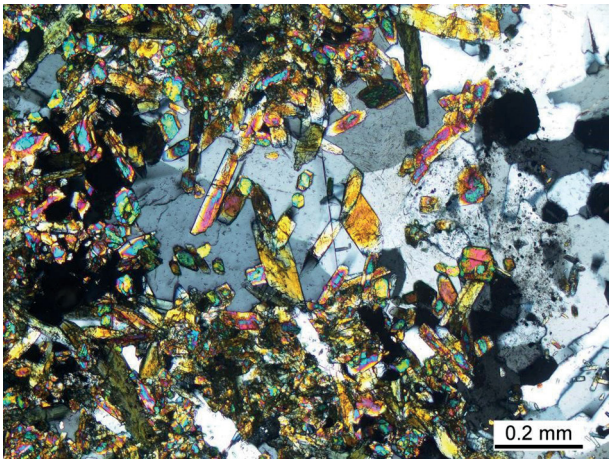

Fig. 9. Transmitted light microscopic image of euhedral prismatic epidote (multicoloured) in silicified wall rock (greys), crossed polariser.

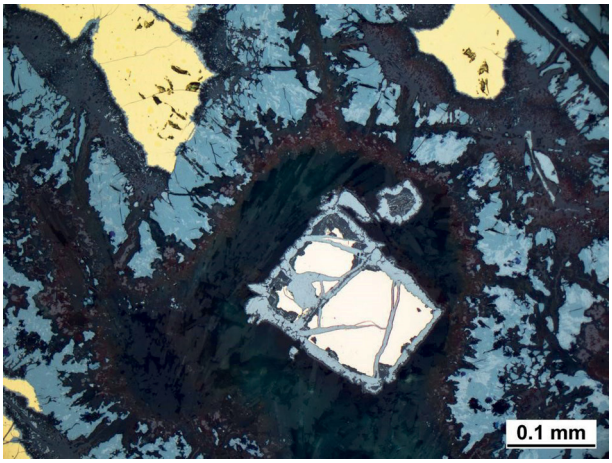

Fig. 10. Reflected light microscopic image of pyrite (light grey) replaced by haematite, chalcopyrite (yellow) corroded to limonite (dark) surrounded by chalcocite (steel-grey) and covellite (blue-grey), parallel polariser.

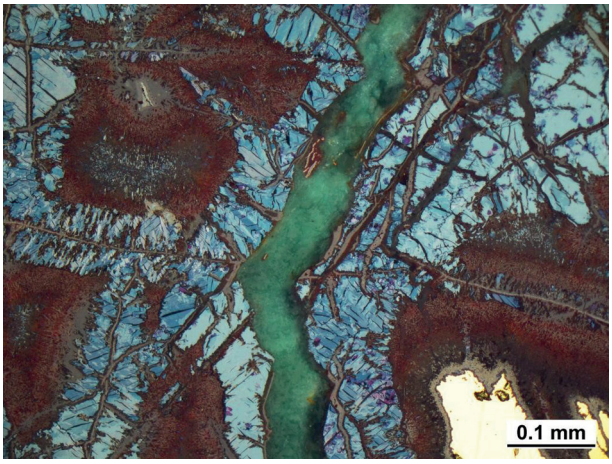

Fig. 11. Reflected light microscopic image of chalcocite (steel-grey) and covellite (blue) forming a cellular network around corroded chalcopyrite (yellow) replaced by limonite (dark-grey reddish), cross-cut by vein filled with malachite (green), parallel polariser.

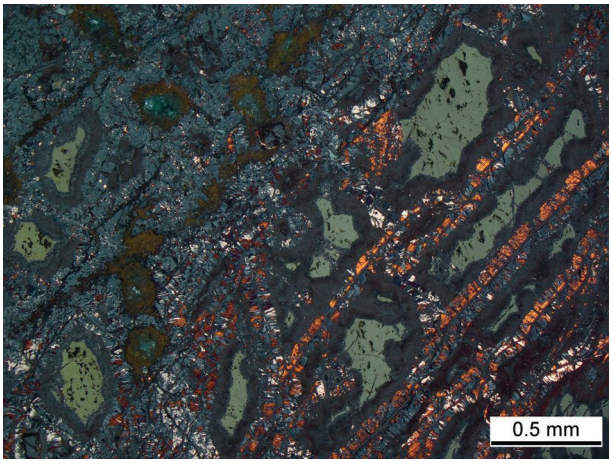

Fig. 12. Reflected light microscopic image of chalcopyrite (light yellowish-grey) overgrown by secondary copper sulphides chalcocite (grey) and covellite (orange-red) exhibiting anisotropic colours, crossed polariser.

replacing cubic magnetite. The latter most likely being relicts from the host rock. Bordering subhedral to euhedral quartz crystals, relict pyrite and chalcopyrite occur. Pyrite is present as partly oxidised relict cubes replaced by anhedral haematite along grain boundaries (*fig. 10*). Chalcopyrite may exhibit a distinct anisotropy. Often observed are triangular to quadrilateral shapes of chalcopyrite, being corroded by limonite and enveloped by a net of secondary copper sulphides, chalcocite and covellite. Resulting from that are angular cellular patterns with thin parallel walls. Chalcopyrite replacement by limonite was observed to happen along crystal planes cross-cutting the crystallites or along the grain boundaries forming rounded shallow embayments. A complete alteration of chalcopyrite is possible, whereas pseudomorphic replacement by limonite redraws the original texture (*fig. 11*). The cell wall structure overgrowing the replaced chalcopyrite is formed of chalcocite in parts intergrown with blue covellite, expressing distinct orange anisotropic colours (*fig. 12*). As with chalcopyrite an alteration of the secondary sulphides also occurs, resulting in corroded grain boundaries. Non-opaque green secondary copper minerals form fillings (*fig. 11*) in vugs or along

cracks. These phases display radial fibrous crystallites typical for malachite. SEM-EDS investigations confirmed finds using optical microscopy. In some cases, very minute crystals of chalcocite are overgrown by malachite.

Compared to the site of Propadnala Voda, the mined vein deposit at Varli Bryag represents a less oxidised vein deposit. It is most likely that the mineralised veins of Medni Rid exhibit similar mineralogical characteristics in different depths.

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and Kalin Dimitrov

Results of the Field Survey in Combination with LiDAR Laser Scanning in the Medni Rid Area

Keywords: Bulgaria, Medni Rid, Mining Archaeology, LiDAR

Current State of Research

In recent years, increased efforts have been waged in order to put together a detailed, archaeological picture of the prehistoric Black Sea region. Since the end of the 1990s, a considerable amount of new information on prehistoric settlement patterns was gathered as a result of off-shore surveys, which extracted samples from 4 to 8m below sea level (Draganov 1995; Лазаров 1996; Filipova-Marinova 2007; Angelova/Özdoğan 2013).[1] Multiple radiocarbon dates taken from excavation sites in the present-day bay of Sozopol, south-eastern Bulgaria, indicate the end of the Copper Age (4,450 to 4,200 BCE), or rather the Kodžadermen-Gumelniţa-Karanovo VI (KGK VI) cultural complex (Boyadziev 1995; 1998; Preisinger et al. 2004; Dimitrov 2007; Dimitrov/Draganov, this volume). The archaeological excavations of prehistoric settlements which lie on the present-day coastline took place mostly in accordance with construction projects for tourist attractions along the coast, which therefore meant that the excavation sites needed to be evaluated and studied within a certain timeframe, adding a considerable amount of pressure. The excavation sites of Atia, Budzhaka and especially Akladi Cheiri are worth noting as they played a crucial role in determining our investigation procedure.[2]

Since the complete account of the knowledge gained from the excavations at Akladi Cheiri is also published in this volume by P. Leshtakov et al. (89–120), this piece will only give a general overview of the individual layers and their relation to metallurgy. In the excavation of the Late Neolithic site were found over 40 ash- and clay-filled pits containing numerous finds, among them heavily burnt daub; intact as well as fragmented ceramic vessels; tools of bone, stone, and flint, as well as a few pieces of copper ore. The documented pieces of carbonated ore – mostly malachite – were neither thermally nor mechanically processed (Rehren et al. 2016, 206), though they indicate a usage during the late 6th mill. BCE. As is presented in the corresponding article in this volume, carbonated copper ore from the 6th mill. BCE is known from other regions, like in Anatolia (Mersin-Yumuktepe XVI, Değirmentepe) and Iran (Tal-i Iblis, Tepe Gabristan), where they were likely used to produce jewellery using cold and hot processing.[3]

As evidence for metallurgical activities may be referenced some scoriated pottery fragments with malachite and melted copper particles (Rehren et al. 2016, 208 f., fig. 3–5) as well as

1 For causes behind the rise in sea level around 4,200 BCE see Konikov 2007.

2 The excavations of the three above-mentioned settlements were led by P. Leshtakov. See Leshtakov 2013; 2010; Лещаков 2009; Лещаков et al. 2009; Leshtakov et al., this volume, 89–120.

3 See Kunze/Pernicka, this volume, 67–86.

numerous pieces of copper ore and two copper awls[4] (Leshtakov 2013, 45 f., Abb. 21.3–4, 22–23). A further, more basic feature – centrally located, about 8m long, and partially destroyed – presents us with more evidence. In this feature, there were found heavily burnt, partially glazed pottery shards, whose interior surface indicated strong fire exposure and evidence of copper smelting (Leshtakov 2013, 45 f., Abb. 24).

Characteristics of the stage of the Late Chalcolithic show up in only a few pits. Numerous shards can be found – a large portion of which are secondarily burned and have scorified surfaces – as well as individual pieces of malachite and remains of oxidised copper. Also worth mentioning is the discovery of an ellipses-shaped crucible with an oval-shaped base. Bits of malachite on the thick, blistered and partially fritted edges indicate heavy exposure to heat as well as copper processing (Rehren et al. 2016). The underside of the crucible is unchanged, indicating that the exposure to heat affected only the top surface. This means that it is unlikely that this crucible was used for ore smelting; it seems as though it was used rather for the smelting and subsequent casting of raw copper (Rehren 2016, 212). In addition, a few pieces of copper ore (mostly malachite) were found.

The large number of copper ore finds in conjunction with the recorded finds and features which show evidence of metallurgical activities present obvious clues of copper production during the 5th mill. BCE – the Copper Age or 'Eneolithic', to use the customary Bulgarian terminology – in south-east Bulgaria and simultaneously confirm theories found in older literature (Коняров 1953; Черных 1978, 19–25; Георгиев 1987, 26–36). Moreover, a complete *chaîne opératoire* of metallurgical production in the settlement can be successfully proven on the basis of the finds of raw material and their finished products.

4 Using the typology from Черных (1978, 19–25), both awls can be dated to the Copper Age. The geochemical examination using x-ray analysis showed that the copper was of relatively pure quality (Rehren et al. 2016, 207).

Methodological Site Inspection Process

One of the more basic goals of the prospections carried out between the years 2013 and 2016 was the identification and examination of old mining relics (i.e. ore pits, mining trenches, traces of ore dressing and smelting, but also settlement and burial remains as well as old path networks) in the centre of the mountainous region of Medni Rid. A uniform distribution of deductive and inductive methods of operation should accompany the project; that is, alongside the direct study of select excavation sites, systematic research of the surrounding micro- and macro-region with regard to naturally and anthropogenically altered landscape has been essential. Many academic disciplines set the guidelines for data acquisition, much of which centres around classic field surveys (*fig. 1*). The reconstruction of prehistoric infrastructure (quarrying and processing of raw materials), trade and exchange in the social system of the eastern Balkans is therefore of essential importance. Geochemical isotope analyses of several stratigraphically secured copper objects from East Balkan grave sites – for example Varna and those from Durankulak which is situated in the ore-poor Dobruja region – indicate not only the aforementioned consistencies in signature with those of Aibunar in central Bulgaria, whose deposits of copper ore are already well-known (Chernykh 1978), but also with non-localised deposits. The secondary copper material in the region under study – in some areas with large amounts of superficially-occurring pieces which can easily be picked up – allows for relatively simple sampling and scientific analysis, which, in turn, enables us to conduct a specific geochemical characterisation of the copper ore as well as of the geological formations of Medni Rid. The results, which are also presented in this volume (Kunze/Pernicka, 391–418), confirm a number of older analyses of copper ore and strengthen the speculation that the area under study could have played an important role for the mining of copper ore in the 5th mill. BCE (Pernicka et al. 1997, 84–87; Dimitrov 2002, 140 f.).

Until now, this area has seldom been studied archaeologically and mining-archaeologically.

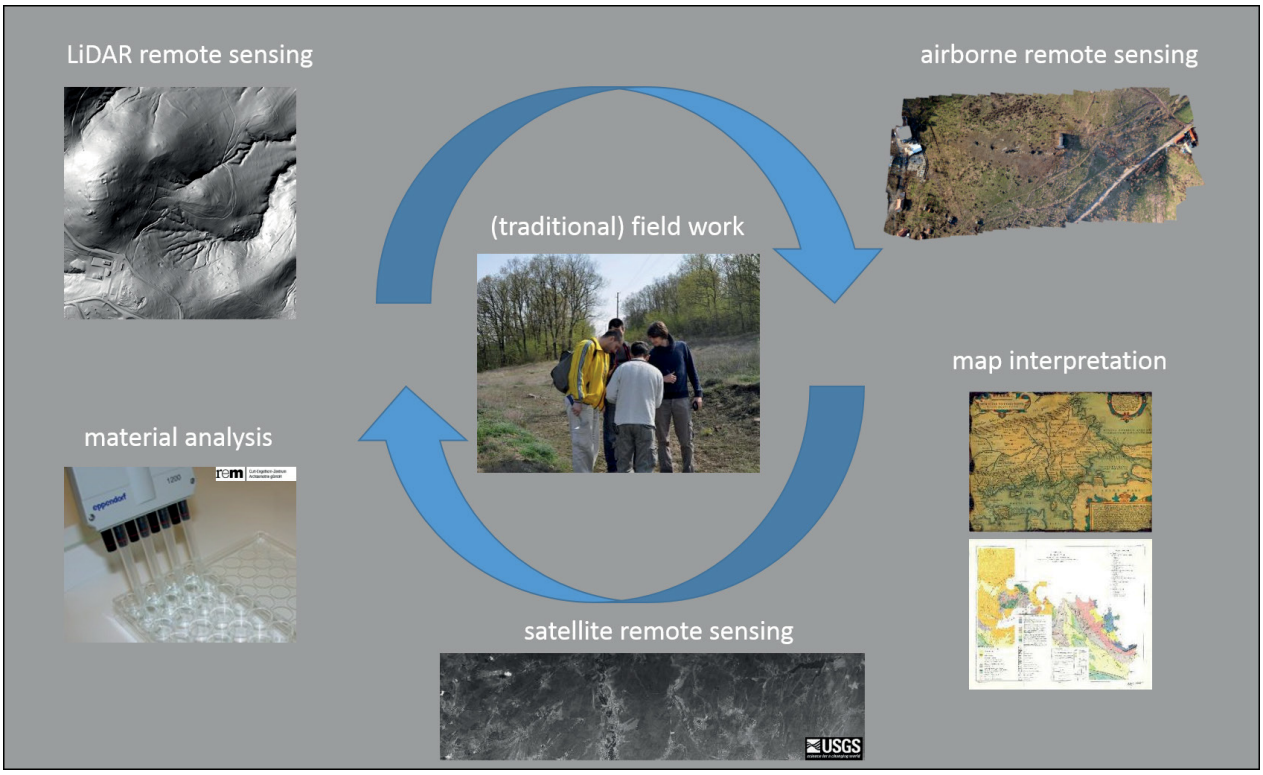

Fig 1. Procedures for data collection in the Medni Rid area and their surroundings.

Apart from surveys and investigations of the mine site of Rosen conducted by E. N. Chernykh (summarised in Dimitrov 2002, 131–135), no systematic work has taken place in this area until the first surveys led by P. Leshtakov during his excavation at Akladi Cheiri (Лещаков/Класнаков 2011, 581–585). The area to be studied presents a well-equipped natural and cultural region, all of whose features will be thoroughly documented and made to be tangibly understood with regard to its contexts. To this end, the natural dimensions, geometry and morphology of the area are enclosed within a natural topographic border made up of the present-day coast of the Black Sea to the east, the Gulf of Burgas to the north, and the rivers Diavolska to the south and Rosenska to the west (*fig. 2*).

The flat planes to the west and the east of Medni Rid present optimal agronomic conditions due to the extremely fertile black soil (Венедиков 1976, 128–131). The name 'Medni Rid' is a direct translation of the Turkish Bakarlaka (Bakırlık) – which today only refers to the highest point of the mountain range – and portends to the use of copper ore in recent history.

While evidence of ore mining from antiquity onwards is available in written records and perhaps also in sealed archives, the only sources of evidence for prehistory are the *in situ* traces visible on the present-day surface. All the more, traces of prehistoric mining in Medni Rid are increasingly challenging to locate due to the historical and modern ore mining which has masked or destructed older mining traces.

Up to now, over 80 findspots – including ore deposits, traces of partially fortified settlements, burial mounds and metallurgical smelting spots – have been found and documented. The evidence of metallurgical ability as a result of the examination of the above-mentioned Copper Age settlements shows, at least indirectly, an easily recognisable chain of metallurgical activity, beginning with ore extraction through to the production of the artefacts themselves.

The intensive and systematically-conducted field surveys in the area under study managed for the first time to document and reconstruct traces of mining independent of their respective chronologies. The initial phase of the survey was based

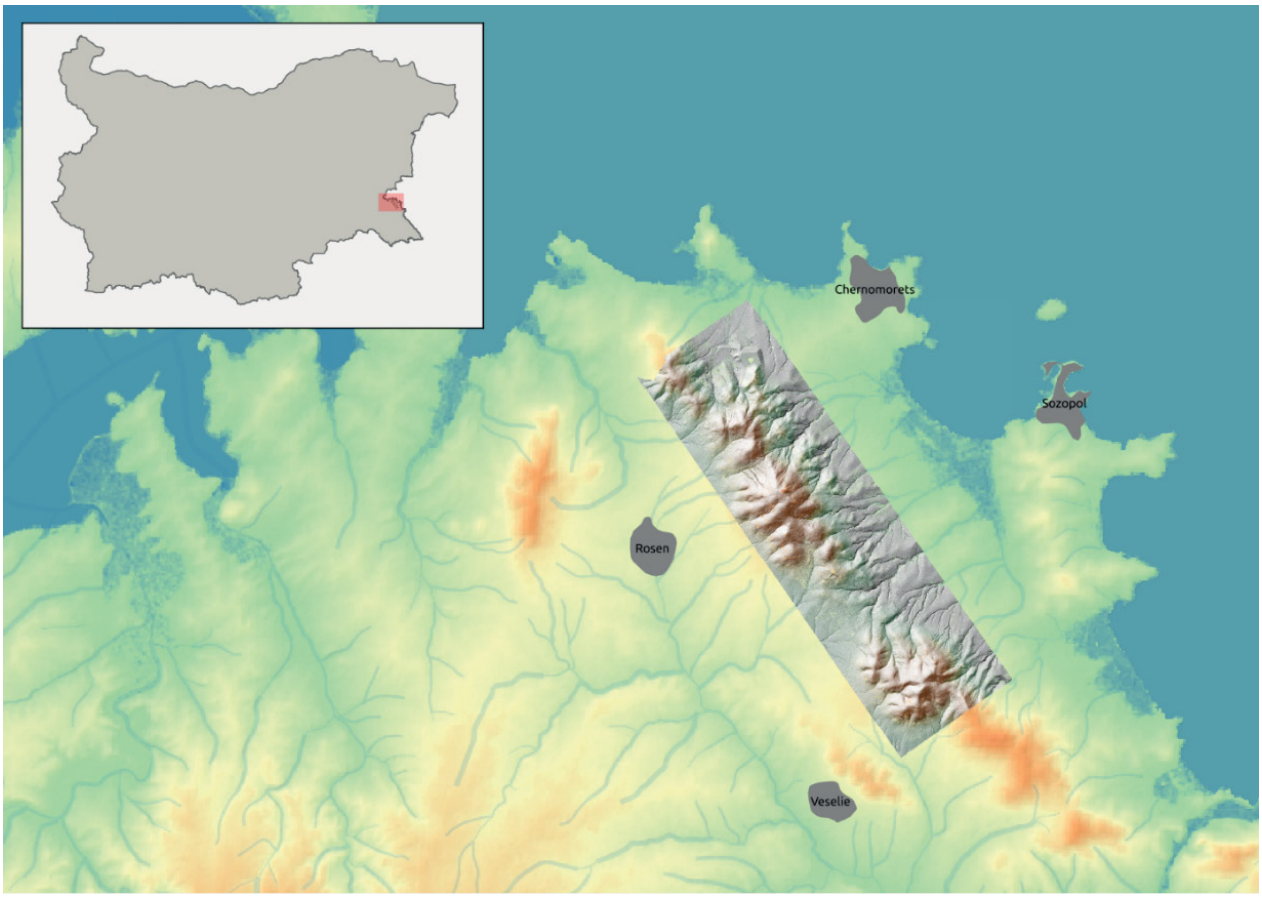

Fig 2. Situation of the research area in south-eastern Bulgaria and the north-west/south-east oriented transect for LiDAR.

on a Partial Coverage Survey.[5] The conduction of the field surveys, however, was met with mild difficulty, as about 70% of the area is covered in thick vegetation. Besides limited visibility as a result of this dense overgrowth also the partially big difference in altitude (between 40 and 376m above sea level) made the work more difficult.

It is very time-consuming to provide a complete overview of traces visible throughout the microtopography even in the case of localised mining-archaeological structures. Even to the trained eye eroded or overgrown features in wooded areas are not immediately recognisable, and the vegetation in these wooded areas makes exact measurements using GPS considerably more difficult. But as the surveys from the years 2013 to 2016 were able to demonstrate, there are numerous mining-archaeological structures present in the area of study, some of whose features are delineated quite clearly as reliefs contrasting with the surface on which they stand. It is worth noting, however, that the state of knowledge concerning the archaeological landscape is incomplete due to the natural conditions and the size of this area. Another issue is presented by the varied possible interpretations of the mining relics. Here therefore, a uniform terminology according to a recognised classification from J. Večeřa during our field survey was used (Večeřa 2013).

In recent years, a considerably more efficient method for examining mining-archaeological landscape structures as well as archaeological settlement remains has proven itself to be the precise recording of the terrain topography by means of Airborne Laser Scanning (ALS) and LiDAR (Light Detection and Ranging) (Holden et al. 2002; Bofinger 2007; Tcherkezova et al. 2014; Falke

5 Measurement of relevant structures and finds was successfully conducted using handheld GPS devices with an accuracy of ±3m (model: Magelan Mobile Mapper CX).

Wave length [nm]	1550
Scan method	Rotating polygon mirror scanner
Pulse energy [µJ]	7,5
Pulse length [ns]	< 3
Pulse Repetition Rate [kHz]	400
Effective Measurement Rate [kHz]	266,6
Pulse recording	Full Waveform
Pulse sampling interval [ns]	1
Scan Angle [°]	±30
Average altitude above ground [m]	550
Spot Diameter on the Ground [m]	0.165
Average point density [Pts./m²]	> 10
Height Accuracy [m]	≤ 0.07
Planimetric Accuracy [m]	≤ 0.15

Table 1. Parameters of the flight.

2013; Haupt et al. 2012; Doneus 2013, 208–222). As a result, a high-definition terrain model of Medni Rid's central region using LiDAR was rendered in February of 2014 by the company EUROSENSE.[6] The north-west/south-east oriented transect has a length of ca. 12km and a width of ca. 3.5km, and a total area of about 40.6km^2 (see *fig. 2*). The acquisition of data was made possible using a LiteMapper 6800 LiDAR laser scanner (*table 1*).

The density of the intended measurements is often composed of several points per square meter and thus makes possible the very detailed calculations of terrain models, able to recognise even the slightest topographical changes in relief.

Besides the possibility of a comparatively quick measurement of the surface terrain of large areas, this method is especially important for the analysis of wooded and hard-to-access areas (Bofinger 2007, 16). The exact location of prehistoric mines and their metallurgical backgrounds using ALS is not, however, without problems, as the area under research has been intensely exploited over several millennia due to its easily extracted copper and iron ore deposits, including the prehistoric mining complexes, which are then irrevocably damaged or destroyed as a result of their continued usage. It is not a surprise, therefore, that there was no directly visible evidence of prehistoric mining activity in the settlements along the banks of the Black Sea at the start of our investigations.

Locating Relevant Sites

The goal of our surveys during the years from 2013 to 2016 was to complete a prospection of the surface of the hilly countryside surrounding Medni Rid and the adjacent areas. New places for excavation were sought in addition to those already familiar to us in order to broaden our knowledge of the (mining-)archaeological network in our region of study. This should include, above all and where possible, the reconstruction of the early use of copper raw materials and their importance for central areas of metallurgical activity during the Chalcolithic period. The areal prospection was carried out using retrieval and mapping of surface material finds as well as using topographical and other relevant features (for example soil marks, conspicuous stone formations,

6 The authors wish to express their gratitude to EUROSENSE represented by Rolf Wilting <www.eurosense.com> (last access: 28.05.2020).

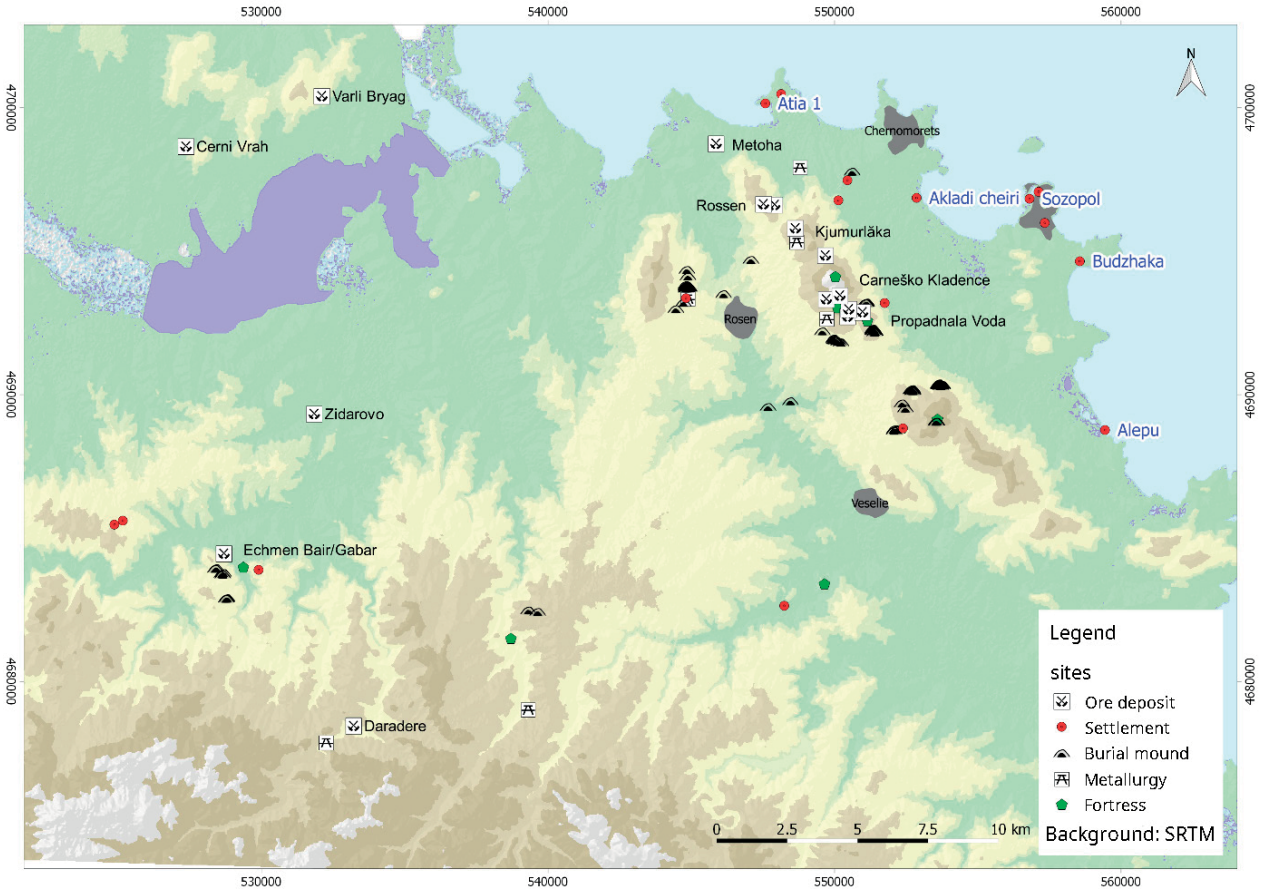

Fig. 3. Topographical overview of the survey area with the central region, the highlands of Medni Rid in the north-east and the plotted sites.

and others). The terrain – largely inaccessible and characterised by dense vegetation – rendered traces of ancient mining complexes and their features for the most part invisible. In this case, the use of the aforementioned non-invasive survey methods (i.e. Airborne Laser Scanning) seemed to be the most effective way to achieve our documentation goals.

After the preparation of the data sets and computational settings (e.g. Hillshade, Laplace Filter and Low-Pass Filter) in Saga-GIS, the data were transferred to the existing GIS for further processing.[7] This is composed of a QGIS connected to a Postgresql databank with a Postgis geographical expansion, with which measurements and documented information were gathered. The different settings were put to use on archaeological and mining-archaeological structures; potential find spots and suspicious-looking areas were digitalised and separated in the databank in order to ensure the distinction between verified and unverified structures. The localised anomalies were more closely examined in the aftermath of the goal-oriented surveys of the terrain. Since, alongside the (mining-)archaeological interpretation, modern mining activity, forestry, and other factors, must be taken into account as landscape-forming factors, the genesis of many of the finds can only be recorded on-site. To this end, for example, several round depressions mostly visible using LiDAR are worth mentioning, some with diameters of a few meters, which can only be addressed in the context of the terrain itself.[8]

7 The individual processes in association with LiDAR data are presented in their entirety in Kunze et al. 2018.

8 See the following section on ‘Ore Localities’ for more information on differentiating between ore pits and ‘natural’ depressions.





Fig. 4–5. Modern mining relicts. Left: disused shaft frame on the place Medni Rid Mt.; Right: portal of an adit near Propadnala Voda.





Fig. 6–7. Indications for modern mining. Left: depression close to Kyumyurlaka; Right: Shaft for ventilation or sinkhole close to Propadnala Voda (approx. 40m depth).

Eighty localities overall were documented during the survey, as is confirmed by the LiDAR databank. This data is currently being processed, and a general overview of the results will be available to view in a public databank.[9]

The assessment of the relics touches upon the categories of ore localities (mining trenches, ore pits, and others), spots of metallurgical activity (ore dressing and smelting), locations of settlements and burials as well as other physical abnormalities like evidence of old paths or (artificial) ditches (*fig. 3*).

Ore Localities

Old adits, hoist frames and other mining structures from the 20th cent. near Propadnala Voda, Rosen Mine Site and Medni Rid Mountain are evidence of intensive underground digging even in the modern-day due to the rich ore deposits (*fig. 4–5*). Local activities in the subsoil of the area indicate several round depressions (*fig. 6*) which should not be confused with ore pits that appear similar. These are namely due to natural processes indirectly influenced by anthropogenic underground mining activity (Večeřa 2013, 55).

Because of this, terminological distinctions like ‘sinkhole’ and ‘depression’ are conducive to our understanding. Many smaller depressions with varying diameter size can appear similar in terms

9 The interpretation of the LiDAR data resulted in a large number of suspicious situations which cannot all be completely tested.

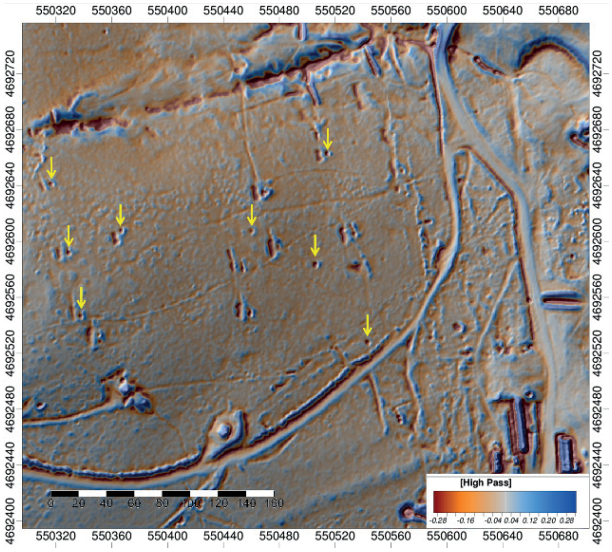

Fig. 8. Depiction of the depressions in a laser scan which was localised during the prospections southwest of Propadnala Voda (filtering though the DTM by using the 'high pass filter').

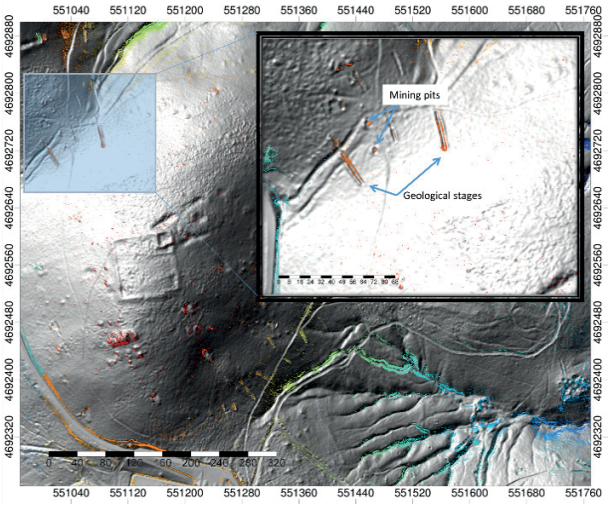

Fig. 9. Marking in colour of the removed grid cells during the filtering of the ground and nonground grid cells. Here evidently many grid cells from particularly striking structures such as ore pits (at the deepest levels) or also modern exploratory trenches are removed.

of shape and do not show any indications of excavated material (spoil) at the edges. Oftentimes there are further indications of modern prospection work in the area, for example, remnants of drilling cores. Depressions, for instance, are not clearly picked up by Digital Terrain Model (DTM) because of their size (which can be up to 3m in diameter) and, in some cases, their lack of depth. An interpretation proves difficult as it would be based mostly on images with a high amount of shadow. The depressions covered by large amounts of vegetation can, for the most part, be made recognisable using a combination of shading/hillshade models and High Pass filters (*fig. 8*). In individual cases, we were able to document large, deep 'pits' whereby it was difficult to distinguish whether they were depressions/sinkholes or intentionally placed shafts for artificial ventilation (*fig. 7*).

Unlike the depressions, ore pits and mining trenches are easily distinguished in the terrain from both natural and modern-day features. Due to the linear, subvertical structure of the orebodies, old mining features often appear as trenches (*fig. 9*). Alongside relatively imposing mining trenches – in some cases 15m wide and 3m deep, such as Propadnala Voda or Zidarovo – ore pits appear in Medni Rid mostly as small, round formations, particularly arranged as a chain or a field of ore pits. Both are open-pit mining sites ranging in size, intentionally designed for ore extraction and which follow the lode only slightly beneath the surface (Falke 2013, 23; Večeřa 2013, 55).

A relatively substantial chain of ore pits, known as Kyumyurlaka (Korucheschme), can be recognised easily in Orthophoto or in the laser scan. The ore pit workings lies approximately 1km south of the old mineworkers settlement of Atia near the Rosen Mine Site at about 200 to 220m above sea level (coordinates: 42.41275°N, 27.59108°E).[10] In total six ore pits are visible here, some with notably large diameters of up to 30m and depths of up to 25m. There are numerous indications of modern usage: several depressions, concreted shaft entrances, the size of the ore pits themselves and the remains of a superstructure strewn about. Intriguingly, a large smelting site with remnants of copper slag, mortars, pieces of scoriaceous pottery and stones from the walls of the smelting ovens can be found only a few hundred metres deeper into the valley and could indicate a direct connection to ore extraction (known as Kyumyurlaka metallurgical place).[11]

10 All findspots are based on geographic coordinates according to the World Geodetic System (WGS) 84.
11 See section on metallurgical activity sites.

Chains of ore pits were often observed in the area under study which were retroactively connected to each other via a network of chutes and channels, which, in turn, through 'indirections', led to a superficial open-pit mine or mining trenches. Traces of old mining activity of this kind can be located within the investigated area in sites such as Golyam Rosen Bair and Surneshko Kladenche (in the context of further, larger single ore pits) as well as north of the central area, for example in Varli Bryag and Cherni Vrah. Numerous chains of ore pits (ca. 30 x 25m) were created and interconnected in the site of Golyam Rosen Bair (coordinates: 42.42056°N, 27.57761°E, ca. 180m above sea level) north of where Atia is located. Furthermore, a number of short, modern prospection trenches can be seen in this area. To the south-west of the trench a 2m long row of 80cm large stones in a square formation were observed, highly reminiscent of a passage tomb. In Surneshko Kladenche, about 800m south-east of the highest point of Medni Rid (Bakarlaka), multiple ore pits run along the ore vein in a north-north-east/south-south-west direction (coordinates: 42.39391°N, 27.61786°E, ca. 280m above sea level) and were also retroactively interconnected to a mining trench.

The impressive depths and length of the mining trenches of Varli Bryag and Cherni Vrah are located north-west of our area of study, near to the city of Burgas.[12] Both ore localities were structured in accordance with the previous example of a chain of ore pits which then interconnected to a mining trench. They, too, are set up along the north-north-east/south-south-west ore veins. Due to the dominance of secondary copper minerals over relict copper sulphides, which can be ascertained macroscopically, it appears – at least in Varli Bryag – that both are oxidic intermediate deposits, whose oxide zones, according to K. Dimitrov, extend to a depth of about 50 to 60m (Dimitrov 2002, 131). The secondary copper materials appear disseminated and irregularly overgrown in their ore alongside metallic hematite. It is likely that copper carbonate (malachite, azurite) in addition to copper sulphite (chalcanthite) is present. Shiny, yellowish sulphides, pyrite and chalcopyrite can also be secondarily identified. These are often either fossilised or already relegated into secondary minerals. Due to the results of geochemical analytics (pRFA), accessory amounts of sphalerite and galenite – or their oxidised counterparts – are likely to show up in the sulphide-rich central area.[13] The site of Varli Bryag continually shows up in prehistory as an important ore deposit without clear evidence as to why. To this end, systematic research of Cherni Vrah is insufficient (*fig. 10*). According to a personal statement taken from one of the current inhabitants, the mining trenches were a modern instalment, and underground work has taken place in the second half of the last century. What has actually been dismantled in this area remains unknown.

A widespread field of ore pits in Medni Rid could not be documented, but such features do exist in the extended area of our investigation, for example in Daradere (coordinates: 42.25750°N, 27.40296°E, 140m above sea level). Here, ore pit fields of varying shape and form are systematically laid out (*fig. 11*). The extracted ore was smelted only a few metres away, as is evidenced by numerous massive pieces of slag near a small river, the Tiasnata.

Traces of mining trenches placed in order to extract ore lying close to the surface are situated directly on each lode, which enabled the ore to be easily extracted using simple tools. The resulting mine spoil was stored directly on the premises in dumps. Distributed along the entire area of study small trenches are found, mostly documented in wooded areas. Despite clear anthropogenic origin, there are two potential uses. These trenches frequently appear at the sites of Metoha and Alatepe but are not as widespread. These might, in fact, be considered rather as small trenches used for ore extraction or prospection. Another explanation could be taken from the small ditches surrounding Propadnala Voda, Rosen Mine Site, Surneshko Kladenche and Karakachanski Kolibi. The similarly straight, narrow, funnel-shaped ditches which,

12 Varli Bryag: 42.45532°N, 27.39070°E, 111–129m NN; Cherni Vrah: 42.43877°N, 27.33335°E, 52–63m NN.

13 For a detailed morphological and geological description of Varli Bryag, see Tim Rödel, this volume.

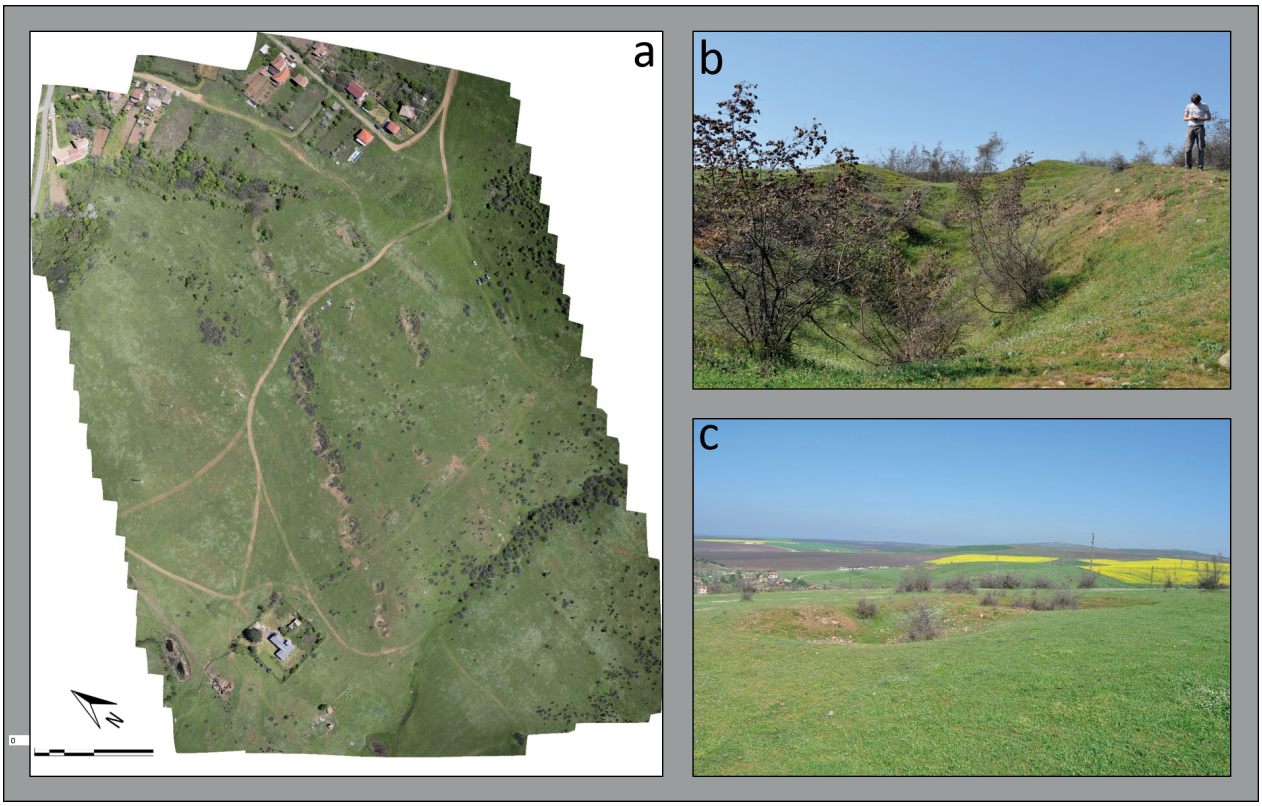

Fig. 10. Findspot of Cherni Vrah: a) aerial image (compound) of the mining trench; b) detailed view of the mining trench; c) many depressions (?) due to underground mining (?).



Fig. 11. Findspot of Daradere. Field of huge ore pits.

during the initial prospection were interpreted as small mining trenches, appear now after much consideration to be artificial ditches, for example anthropogenically constructed water inlets directed towards the extraction centres (Propadnala Voda, Rosen Mine Site, Surneshko Kladenche) and/or the smelting sites (Karakachanski Kolibi).

The anomalies sound in the vicinity of Propadnala Voda are amongst the most significant results of the interpretation of LiDAR dates. The region itself is actually located in the central part of Medni Rid, about 6km west of Sozopol. Alongside the aforementioned mining relics (hoist frame, adits, ca. 13 'modern' depressions in the surrounding wooded areas) and a central mining trench were documented both a large, fortified settlement (Chiplaka) as well as a pre-modern field of burial mounds (Kokardzhata). This location conveys a general idea of the archaeological landscape and presents itself as a joint complex, which possibly developed as a result of encountering the existing raw materials (*fig. 12*). This assumption is supported by numerous finds of copper and iron slag and stone tools used for crushing ore as well as large amounts of surface finds, among which are remains of ceramics from the late 6th and early 5th cent. BCE, which indicate at least a pre-modern use of the area. The visible part of the deposit is identified by a ca. 200m long, ca. 25m wide mining trench, running west to the east upon a mountain slope (coordinates: 42.38535°N, 27.61380°E; 190 to 240m above sea level).

T. Rödel classified this locality as a typical representative of oxidic lode ore (Kunze et al. 2018).

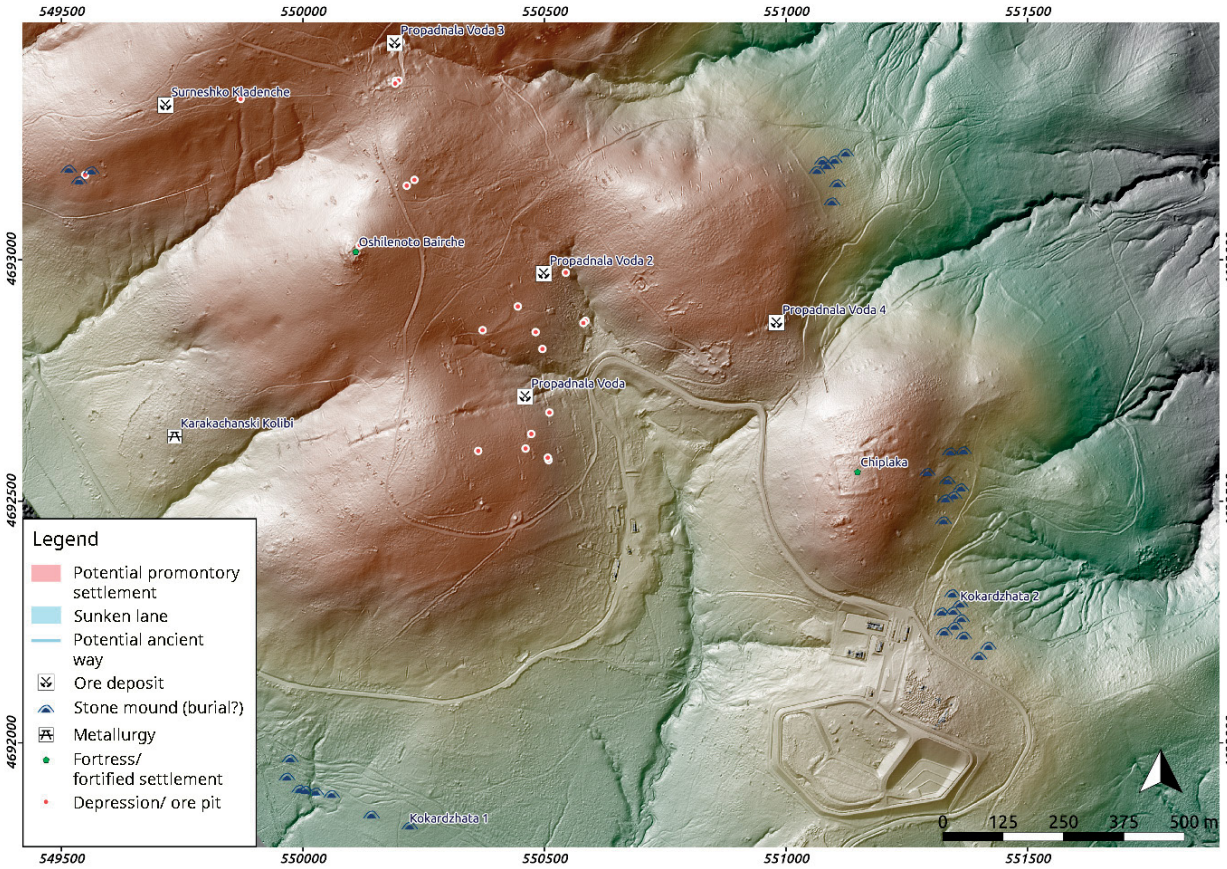

Fig. 12. Environment of Propadnala Voda.

Characterised by orange to the red-brown ferruginous crust as well as grey or grey-white fieldstones, they give an indication of mineral alteration, particularly of clay minerals like kaolinite, smectite and montmorillonite. The original rock was presumably magmatic diabase, for example, volcaniclastic rocks. Small, turquoise or green/azure veinlets and efflorescences running through the rocks are particularly noticeable. These fine veinlets appear vitreous (amorphous). These specific features could be due to the presence of copper carbonate (malachite, azurite), copper sulphides (e.g. chalcanthite) as well as copper silicate (chrysocolla), which form a large group of minerals with varying chemistry. The vitrious appearance and characteristic colours could indicate the presence of chrysocolla. Elevated levels of uranium are also striking. The radiation dose rate of the ore in Propadnala Voda is, according to our own analytical determination, 0.5µS/h to 0.8µS/h, compared with 0.15µS/h in Varli Bryag, for instance – slightly elevated, but significantly higher values are indicated underground (see Пресиянов/Димитров 1998).

Two round, red soil discolourations documented to the right of the entrance to the wooded area facing uphill stood out in particular, which could possibly be interpreted as the remains of a former smelting site or roast bed.

We located the fortified settlement of Chiplaka (coordinates: 42.38399°N, 27.62170°E, 212m above sea level) about 600m away from the above-mentioned mining trench and the modern street. The wall-like structures with a regular ground plan (ca. 80 x 80m) – clearly visible in the elevation model (*fig. 13*) – are also easily recognisable in the area: up to 1.5m high and with an additional, fortified area in the north-east corner. Inside of the complex, which, without vegetation, would offer a view of the black sea coast as well as to the ore deposits, more rectangular, stone-lined ground plans are located, which could be interpreted as house structures. The sparse pottery finds indicate an occupation in early to late Antiquity. This date

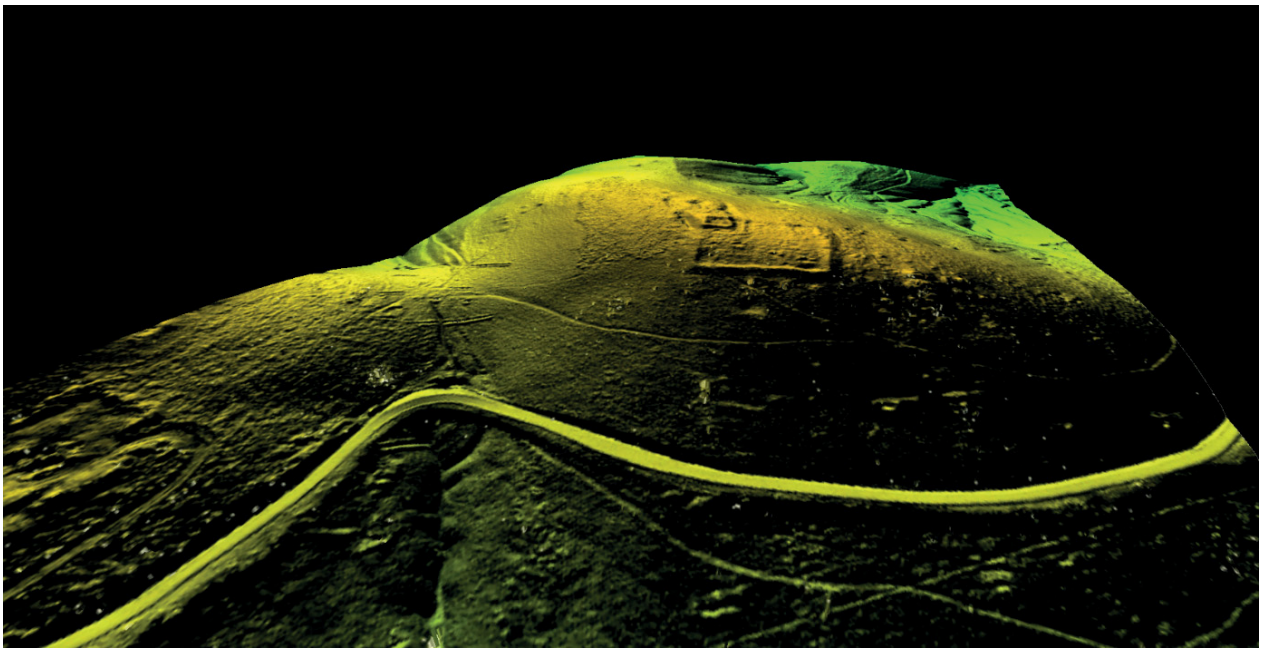

Fig. 13. Fortified settlement of Chiplaka. View in eastern direction.

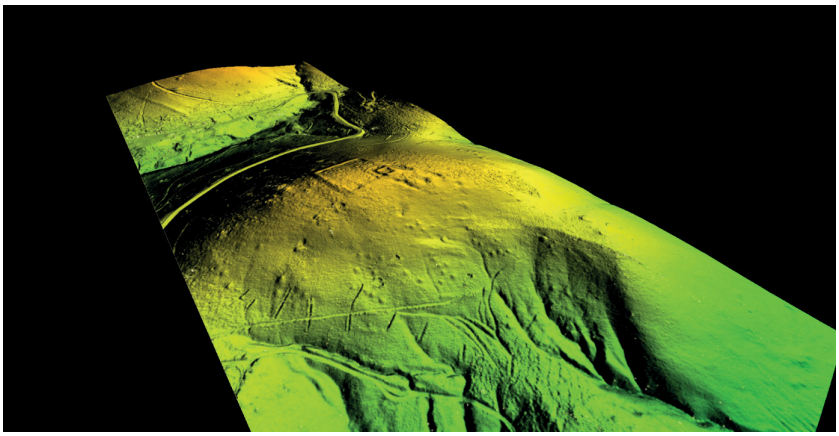

Fig. 14. Fortified settlement of Chiplaka with an adjacent cemetery of burial mounds (view in north-north-western direction).

could also apply to some burial mounds located south-east of the complex. About 300m away from the fortification a number of burial mounds with similar measurements were documented within a 1.5ha area (coordinates: 42.38076°N, 27.62378°E, ca. 170m above sea level). Rows of graves along the hillside further east of this area might also belong to this context (*fig. 14*).

About 700m north-east from the fortified settlement there lies a topographically superbly located area of potential concern which might potentially be another settlement site (coordinates: 42.38934°N, 27.63000°E, 80m above sea level). Two small rivers to the north and to the south cut deeply through the area and intersect again to the east, forming a spur-like, triangular structure, tapering off directly to the east. The natural topography to the north and south is composed of steep slopes with a height of up to 15–25m, creating a natural 'fortification' surrounding the site. The area to the west lies open and was possibly secured by anthropogenically constructed fortifications, which are visible with the help of DTM. The internal fortification is located about 160m west of the 'spur' tip. The distance between the internal and external fortifications is another 320m, making the entire area about 480m long and between 10 and 180m wide – a total of 5ha. Due to the morphological preconditions, one can easily imagine that the actual settlement area only extended to the internal

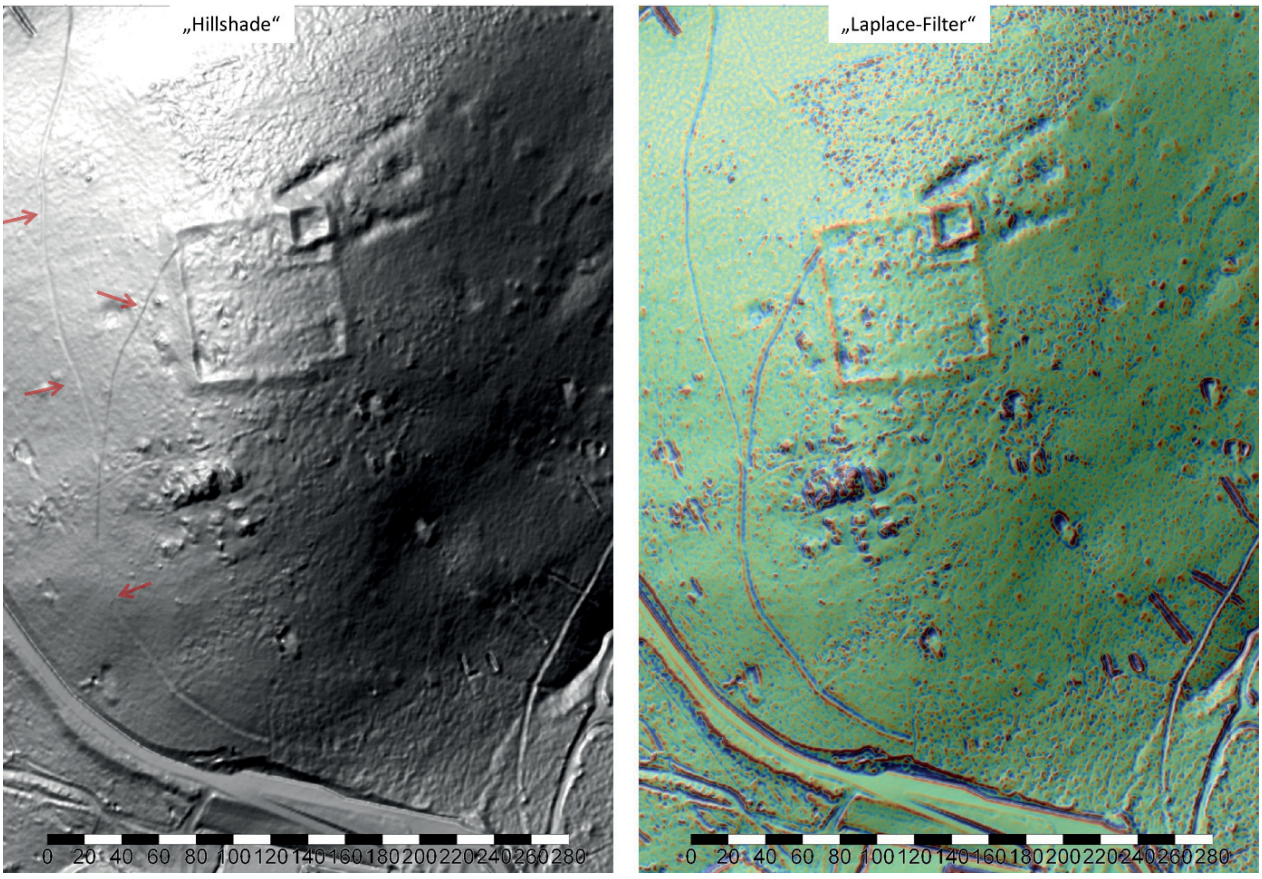

Fig. 15. Modelled comparison of the path of the presumed sunken lane. Left: purely in the shading model; Right: in the 'Laplace filter model' (overlaid shading model).

fortifications and thus occupied a significantly smaller area of about 0.6ha. Several pieces of pottery found on the surface were not indicative of any particular chronological position, but their existence at the very least classifies the area as a findspot with many small burial mounds further west of the settlement (coordinates: 42.38943°N, 27.62077°E, ca. 170m above sea level).

One further category of structures characterises the complex of Propadnala Voda: the old paths and sunken lanes. To the west and south of the fortified settlement Chiplaka a path was discovered with the help of DTM with the additional use of the Laplace and High Pass filters which shows a topographical relation with the fortified settlement (*fig. 15*). In terms of nature, it is difficult to contextually relate the chronological classification and topographic relations of old paths (see Denecke 2007, 628). The above-mentioned path leads to the north-west corner of the alleged settlement. On-site surface investigations could conclusively verify neither an entry point connecting to the path nor provide reliable evidence for a chronological position, so a connection between the path and the alleged settlement has not yet been proved but can at least be assumed.

A similar situation is presented by fans of sunken lanes to the north, south, and east of the fortified settlement with a radius of 400 to 900m. Sunken lanes are formerly used routes (old paths) of local and regional/national importance, which, due to their excessive loads, can no longer be used and thus require at this point a kind of bypass (Straßmann 2004). Several topographical and climatic occurrences, as well as easily erodible geological substrata, necessitate that detours be created, ultimately making available these groups of sunken lanes, which are quite clearly visible using DTM. Sunken lanes are mostly historical relics from Antiquity and the Middle Ages, as the mechanical stress of the paths here was very high. Of particular interest is the appearance of two

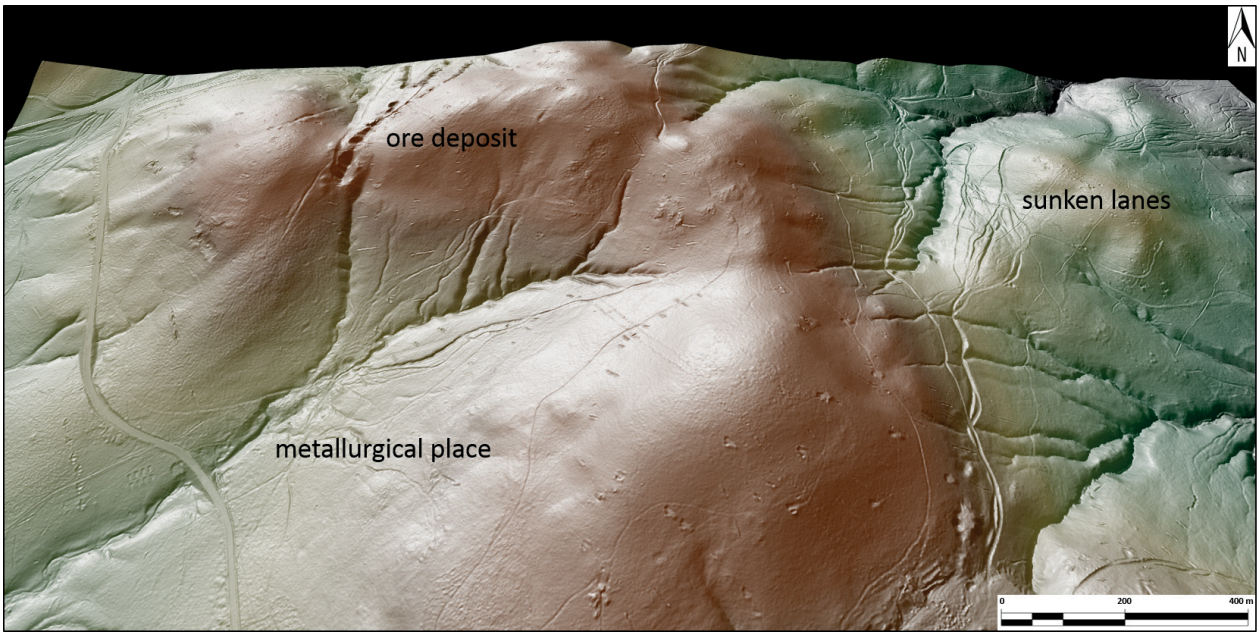

Fig. 16. Findspot of Kyumyurlaka. Relief representation of the ore pit chain (ore deposit) and the ore smelting area (metallurgical place) as well as nearby sunken lanes.

wide-ranging fans of sunken lanes (each about 90m wide) north-west of the triangular settlement area. In this area, we found the substrata to be particularly loamy, which was likely due to constant 'repaving' of the road. Both fans of sunken lanes are sections of two older paths which join together again west of the outgoing settlement area and form a path leading in the direction of Chiplaka and the ore district of Propadnala Voda (see *fig. 12*).

We were able to demonstrate that, in Medni Rid and its surrounding areas, there are many structures which can be connected to mining activities. These not only include the numerous and widely visible remains of modern mining but also, in particular, the mining trenches and ore pits, which, in some places, appear to be quite imposing. The implemented prospection methods – that is, area survey using airborne laser scanning – helped to localise new relics of old mining activities. This allowed for the collection, sampling and geochemical differentiation of copper ore to be used for purposes of comparison (see Kunze/Pernicka, this volume, 391–418). Our surveys were also able to show that mining relics are virtually impossible to date using this method of prospection. Rarely surface finds hint to a chronological date, and this is the case with the pottery fragments from Propadnala Voda as well. Only the spatial context allows to speculate about chronology and potential activities (see Crkal/Volf 2014). Places like Propadnala Voda (ore deposit, fortified settlement, burial grounds, old paths and sunken lanes) or Kyumyurlaka (ore pits, metallurgical centre) act as reference points.

The overall region of Propadnala Voda is exemplary for the emerging framework of a complex structure consisting of (at least) ancient settlements, road networks and burials in which old mining activity appears to have been incorporated. Despite all this, the chronology of the individual structures and the relationship between the individual elements themselves require further investigation and discussion.

Metallurgical Sites

Actual evidence of dressing and smelting of copper ore in specific locations within our area of study could seldom be determined. The results of investigations conducted by P. Leshkatov on the settlement of Akladi Cheiri demonstrated that ore processing did, indeed, take place in the

settlement during the Copper Age. This site is not unusual for the Chalcolithic and is comparable to other, similar excavation sites in Anatolia (see Kunze/Pernicka, this volume, 67–86). It may, then, be assumed from the start that little to no traces of copper processing and smelting are presented in Medni Rid. Additionally, waste products of copper processing are difficult to identify and are seldom found, since the carbonates or oxides, which were probably used here during that period of time, are easily separable from other minerals and a very pure copper was produced during the smelting process, therefore forming a very small amount of slag (Neukirchen 2016, 25).

It was only after the Bronze Age, which coincides with the 'industrial' extraction of ore deposits, that the metallurgical processing locations moved towards the ore deposits themselves. One of these locations is presented by the expansive site of Kyumyurlaka (*fig. 16*). The site, which lies about 3.5km north of Propadnala Voda, is composed of two areas: the first is situated on a slight elevation of 220m above sea level and contains several chains of the aforementioned, sometimes quite far-reaching ore pits; the second is an area of ca. 1ha which is situated 500 m away from the first side at a height of 60m difference in altitude on a downhill slope along a creek (coordinates: 42.40794°N, 27.59056°E, ca. 163m above sea level) which was covered mainly in copper and iron slag. Alongside these waste products further pieces of scoriated furnace wall (Cat.No. 26) were found, that is, scoriated pottery fragments and stones, as well as (iron) blooms and various stone tools, for example, stone mortars used to crush ore (Cat.No. 26). The large amount of slag might indicate smelting of sulphidic ore. Charred wood remains were extracted from two pieces of smelted slag (*fig. 17*) and were examined using radiocarbon dating. The results produced, surprisingly, two distinctly different dates. On the one hand, it confirmed the suspicion that this site could possibly have been a Roman-era smelting site or was used in antiquity. Wood Sample 57 (lab number MAMS 27894) gave a date of around the 3rd cent. BCE (calibrated ^{14}C-date 1765±24 BP, i.e. 171–377 calBCE [2σ]). The dates of another wood sample extracted from slag showed something different: Sample 56 (*fig. 17*; lab number MAMS 24609) gave a date of 4437±31 BP, or a calibrated date of 3329–2929 calBCE (2σ). This date, interestingly enough, reaches back to the first phase of the Early Bronze Age. The older section corresponds to dates from pit graves extending between the Lower Danube and Thrace and the younger section overlaps with the oldest dates from the Early Bronze Age in Thrace (see Kunze et al. 2018). The radiocarbon date, therefore, counts as one of the oldest actual indications of a smelting site in Thrace. Paradoxically, this area represents a conspicuous decline in local metal production in the Balkan area.



Fig. 17. Piece of slag with the remains of wood and charcoal (sample 56).

In sum, the survey prospection results allow us to conclude that this site was most likely a smelting centre for the available raw material – iron and copper – mostly during antiquity. Evidence of ore processing is represented by tools and equipment, the occurrence of subsequent smelting on the one hand evidenced by slag fields and on the other by extant remnants of melting furnaces. On the basis of the concentration of slag, it can be concluded that the metal production here was likely both elaborate and abundant. The accidental discovery of charred wood inside pieces of slag indicates that the area was used as early as the late 4th mill. BCE and suggests that the site went on to be used again in antiquity, at which point it was already considered ancient.

Karakachanski Kolibi is located about 700m west of Propadnala Voda (coordinates: 42.38528°N, 27.60472°E, ca. 184m above sea level). Large



Fig. 18. Find spot of Bakar Bokluk. Heap of slags called Ingelo.

amounts of slag remnants – mostly iron as well as copper – can be found across an unforested area of about 2ha. Remains of initial ore, as well as smelting remnants, were not found. The size of the site, with particular regard to the quantity of slag or the presence of the aforementioned artificial trenches, presumably suggests that the site was quite significant for the extraction and melting of metal. Surneshko Kladenche and/or Propadnala Voda could possibly have served as the ore supplier(s). The large amounts of iron slag suggest that the site was mostly used during antiquity. A possible connection with the fortified settlement of Oshilenoto Bairche, about 500m north-east of the site, is quite likely. In addition, six small stone, which can likely also be dated to antiquity, mounds probably burials in the Karakachanski Kolibi area as well as several others within a surrounding area of 800m were documented (see *fig. 12*).

Not far from the highest point in the mountainous area (Bakarlaka) several (modern) explorations were discovered. Two locations showed evidence of a pre-modern use of the area for metallurgical processing. It includes a round, water-filled pit with finds of typical antique pottery in the surrounding area, and which could be presented as either an ore pit or the remnants of a dwelling (coordinates: 42.39864°N, 27.60114°E, ca. 271m above sea level); possibly it might have been the site of a later usage of an old burial mound for the purpose of ore smelting. It is, at least, what the discovery of remains of the scoriated furnace wall, burnt stones and slag indicates. It is possible that this tiny smelting site is connected to a nearby antique fortification due to the presence of antique pottery.

The fieldsurvey was used to illuminate further the locality of Aivadzhik which is situated about 1km west of the village of Rosen (coordinates: 42.39108°N, 27.54586°E, ca. 120m above sea level). Several house foundations containing pottery fragments suggest a Roman-era settlement, possibly in conjunction with a connecting burial site. Special interest was given to two tools discovered, a pounder and a hammer/pestle, as well as a stone underlay likely belonging to that context used to separate, some surrounding stones, slag fragments and scoriated furnace wall, which all suggest that this was also an area (albeit to a limited extent) where metallurgical processing took place. The required ore for these processes might possibly have been provided by the small mining trenches from Alatepe, which are well within the proximity of the site (coordinates: 42.39772°N, 27.53339°E, ca. 220m above sea level).

Outside of the actual area of study, about 20km south-west of Medni Rid, sites in which extensive smelting of the available ore was conducted are located. It includes the sites of Karausk, Daradere and Bakar Bokluk. Both sites of Karausk and Daradere are located west of the present-day town of Warschilo. Daradere has already been mentioned here due to its connection to a large field of ore pits (see *fig. 11*) and the accumulation of slag pieces in the river Tiasnata. Similarly, more slag fragments are located on the riverbank about 1.3km upstream in Karausk (coordinates: 42.25234°N, 27.39112°E, ca. 160m above sea level).

Both sites could be exemplary of the widespread use of the area for metallurgical processing during antiquity, as indications of metallurgical work exist not only near the Tiasnata. Further and more impressive insights for the dating were gathered just 6km away from the two sites. About 1km south-west of the town of Krushevets the site of Bakar Bokluk on the river Selska is located (coordinates: 42.26238°N, 27.47518°E, ca. 147m above sea level). This site has been continuously connected with the Thracian mining and smelting activities which were continued well into antiquity. During the field surveys, it was possible to document a large amount of slag near the river valley as well

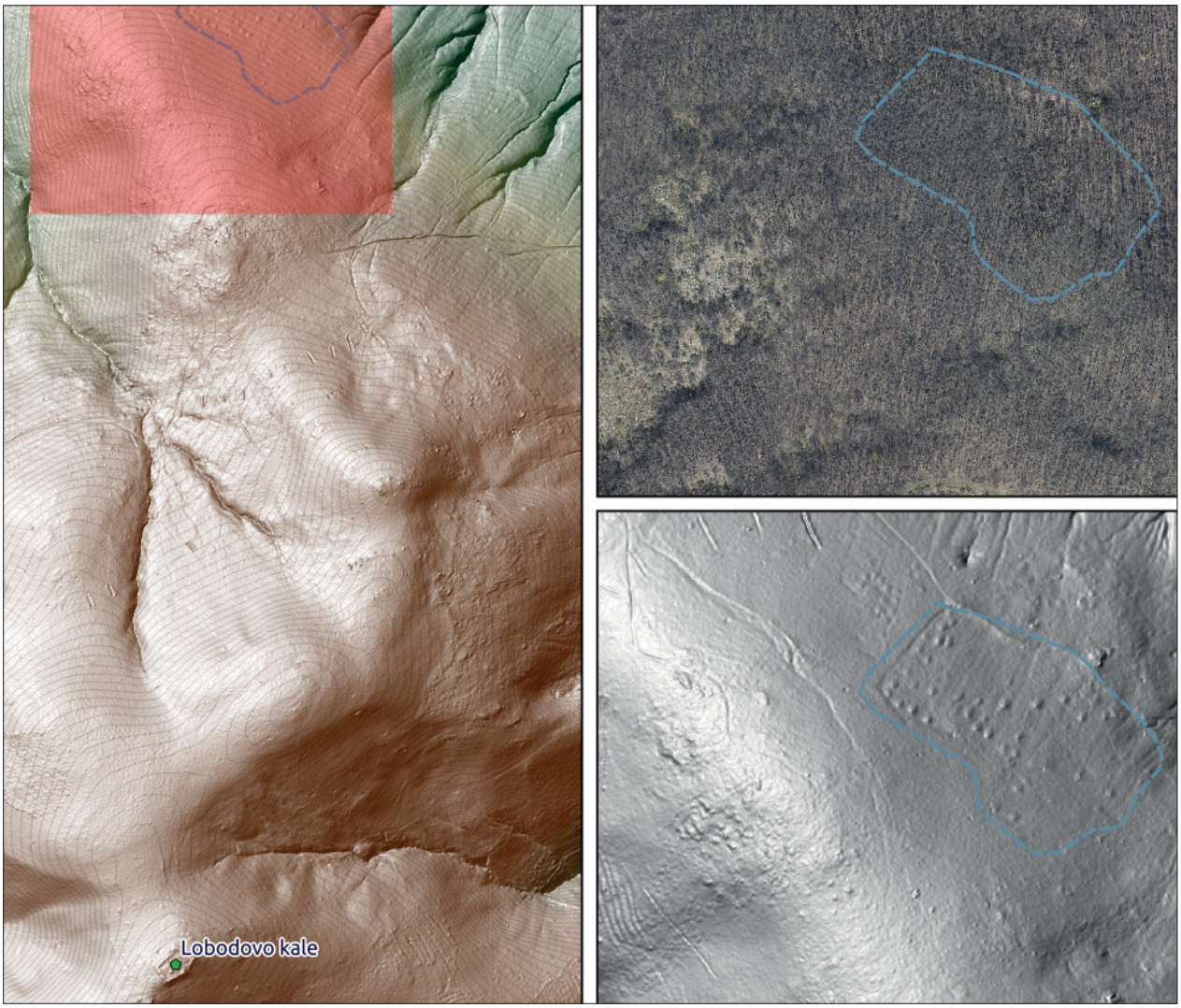

Fig. 19. The surrounding area of Lobodovo Kale fort.

as an approximately 8m high heap of slag (Ingelo) (*fig. 18*). The many pieces of antique pottery we found give us a good idea of the site, which was at least utilised during the Roman era.

Burials and Settlements

In several parts within the investigated area, individual elevated burial mounds (n=16) composed of rocks and soil as well as nine groups of multiple stone mounds, potentially also burials, were documented. As was mentioned, many of these graves are located in close proximity to smelting and ore extracting sites as well as to traces of settlements; this is the case in Aivadzhik, Echmen Bair/Gabar, Lobodova Kale and Propadnala Voda. Apart from the mounds of earth, which can securely be classified as burials, there is a further phenomenon of artificial hill-like elevations distinguishable from burials, appearing particularly in the core area of the Medni Rid mountain range. Here we see small hills made of stone, which are often arranged by small, wall-like structures. In the area surrounding Propadnala Voda four sections with these stone hills were observed (see *fig. 12*).

A further complex, emphasised by its surface, is located about 1.5km north of the Lobodovo Kale fort. In the middle of the woods on a slope facing north-east about 30 of these stone hills varying in size can be found in an area which has boundaries, at least, to the north and the north-west (*fig. 19*).

We can see, in this example, the real benefit of using LiDAR as a prospection method. While normal aerial photos yield fewer results due to the thick vegetation (see *fig. 19*, top right), a variation of small structures could be 'revealed' (see *fig. 19*, bottom right).

No indications for a chronological classification of the structures nor an interpretation of function have yet been found due to the lack of accompanying evidence. Since comparable burial customs are also absent, an interpretation of the stone arrangements as indicative of a burial site is also not possible. But the location of the site indicates that it might have a connection with other sites in the area, and because we are dealing in this case mostly with structures from antiquity, this might serve as a possible clue for dating purposes. One possibility could be a connection with landscape-cultivating measures, such as surface piles. Still, the fact that the piles are almost always located in an isolated section in the middle of the forest and the comparatively structured nature of the stone arrangements seems to contradict this idea. Stone arrangements of this kind also have not yet been observed, even in the areas of eastern the offshoots of the central Medni Rid area which are cultivated intensively, a case that also applies to the areas in the woodlands cleared for modern-day agricultural purposes. We cannot yet, however, exclude the deforested areas that were formerly cultivated, but as of yet there is no evidence which suggests that they would contain any of the aforementioned stone arrangements. The appearance of these stone piles on the steep hillside would also be contradictory.

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Catalogue of Investigated Archaeological Sites and Mining Places

Keywords: Archaeometallurgy, copper mining, Black Sea coast, archaeological survey

This catalogue presents the archaeological sites, and visible traces of old mining inspected and partly rediscovered in field surveys in the years 2013 to 2016 in the area of the copper ore deposits of Rosen, Varli Bryag and Zidarovo (*fig. 1*). The surveys were conducted during autumn and spring in campaigns of about two weeks by a Bulgarian/German team led by Petar Leshtakov. The starting points of the investigations were, on the one hand, the information already systematised by Evgenij Chernykh (Черных 1978) on pre-industrial mining in the region and, on the other hand, the sites newly discovered by Petar Leshtakov (2010; 2013) during his excavations in Akladi Chairi and Budzhaka. Based on these, the study area was systematically expanded. Significant finds were collected, archaeologically determined and documented. The locations were recorded by GPS, and the data was entered into a Geographic Information System.

The catalogue numbers are arranged according to their geographical location, approximately from north-west to south-east. The designation was made either according to the nearest village or according to a known ore field name or relevant toponym. If any differentiations were possible, for example between a mining site, a settlement or a grave, a unique site number was assigned. The listing of several places under one catalogue number occurred in cases where the geographical demarcation was difficult.

The geographical location is given at the beginning of the site description, and the archaeological description corresponds to our admission in the area. The geological-mineralogical description is based both on own observations as well as on evaluations of the publications, specified at the end of the entry.

The structure of the catalogue corresponds to the following form: below the name of the site the geographic coordinates according to the Universal Transverse Mercator (UTM) projection are given. The description lists:

(a) the localisation of the site,
(b) archaeological observations,
(c) indications for archaeometallurgical processes,
(d) geological and mineralogical specifics,
(e) chronological determination,
(f) type and year of archaeological investigation,
(g) bibliographic references.

In field surveys it is often difficult to date the find material precisely. Accordingly, assignments to archaeological periods have to be regarded as preliminary. Throughout the catalogue the designation ‘prehistoric’ simply means ‘before the Archaic Greek period’. Similarly, ‘Late Iron Age’ means roughly the second half of the 1st mill. BC without further specification of a specific subperiod. Whenever it was possible to be somewhat more precise the usual archaeological terminology was used, such as Late Neolithic, Chalcolithic, Early Bronze Age, Classical Greek period (5th and 4th cent. BC), late Hellenistic period (2nd to 1st cent. BC), Roman period (1st to 4th cent. AD), early Byzantine period (5th cent. AD and later).

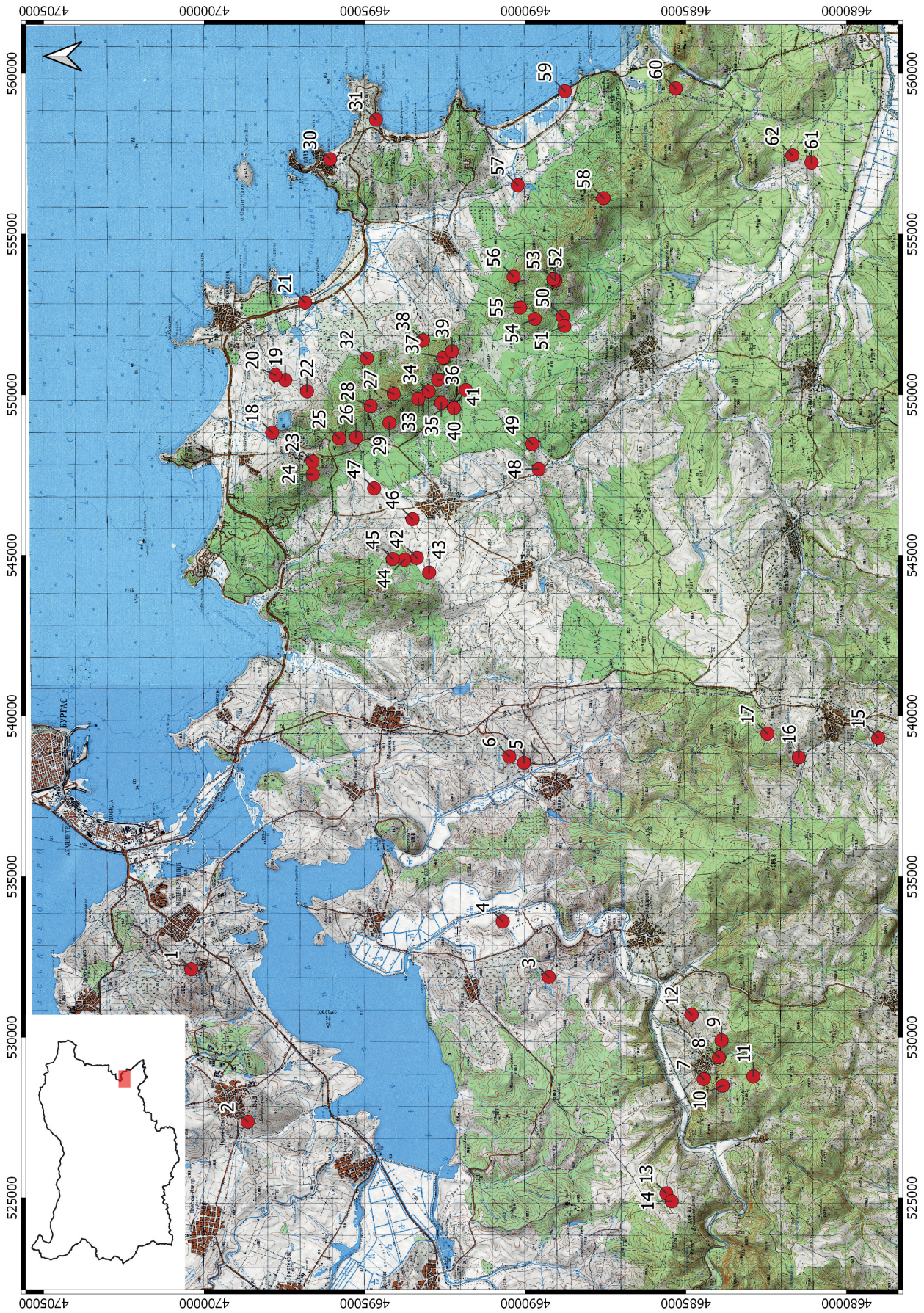

Fig. 1. Map of the research area in south-eastern Bulgaria and the investigated sites.

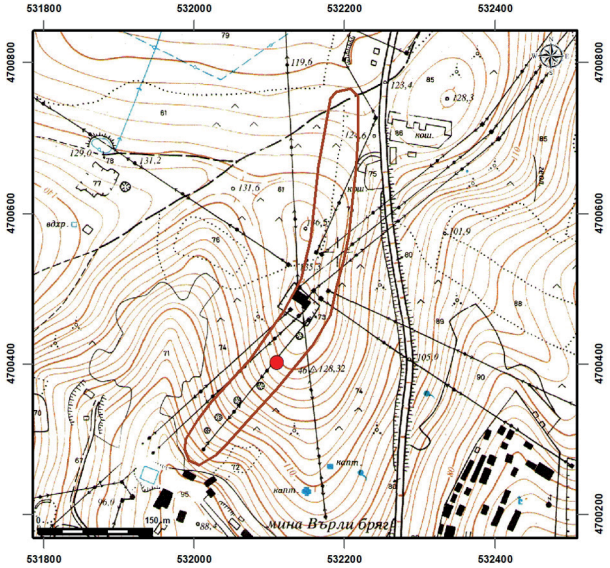

Fig. 2. Location and traces of ancient mining at Varli Bryag.

1. Varli Bryag Mine
35T 532110 4700402

(a) The site is located in the south-west sector of Burgas area, 520m north-west from the centre of the Varli Bryag mining agglomeration. It lies on the ridge and south-west slope of a low hill at the foot of the Shiloto height, between 100m and 135m above sea level (*fig. 2*).

(b) The ancient mine has a linear shape (*fig. 3*) and is traced to a length of 550m. Its average width is 5m to 6m, and in places, it reaches over 10m (*fig. 4–5*). In some uncovered areas, the preserved depth is over 10m. The burrow is traced along the south-east slope of the hill. Archaeological artefacts do not appear in the zone of the ancient mine.

(c) Among the discarded rock pieces rich in secondary copper minerals (malachite, azure), associated with quartz veins are found.

(d) Due to the dominance of secondary copper minerals over relic copper sulphides, which can be ascertained macroscopically, it appears that the mine has an oxide zone that may extend to a depth of about 50m to 60m. The secondary copper minerals malachite and azurite as well as copper sulphate (chalcanthite) appear disseminated and irregularly overgrown in the ore alongside hematite with a metallic hue. It is likely that also copper sulphate (chalcanthite) is present. Shiny, yellowish sulphides, pyrite and chalcopyrite can also be identified.



Fig. 3. Aerial photograph of ancient mine at Varli Bryag, view from the south-east.



Fig. 4. Details of ancient open mine at Varli Bryag.

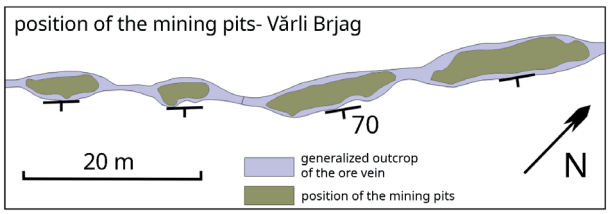

Fig. 5. Simplified depiction of the position, form and size of the mining trenches (grey) in the ore vein (suspected path in blue) of Varli Bryag with basic structural information for the direction and dip angle of the vein (compilation: T. Rödel).

(e) Unclear, Classical Greek and later periods.

(f) Surveys 2014, 2015.

(g) Черных 1978, 19; Коняров 1953, 81 f.; Георгиев 1987, 32.

2. ‘Mining Site’ Cherni Vrah
35T 527367 4698648

(a) The site is situated 950m south-west from the centre of Varli Bryag village, Burgas municipality.

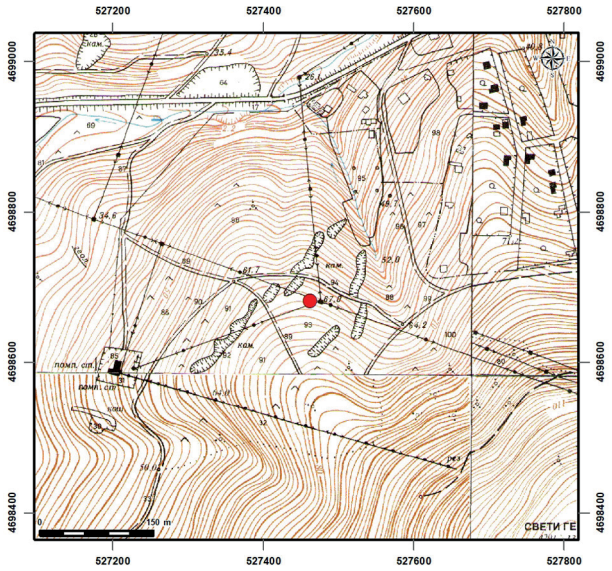

Fig. 6. Location and traces of ancient mining at Cherni Vrah.



Fig. 7. Aerial photograph of traces of ancient mining at Cherni Vrah.

It is located along the north-west slope of the St. George height (*fig. 6*).

(b) The mining activity seems to have begun with a chain of pits which later interconnected to a mining trench along the north-north-east/south-south-west ore vein. The total length of the mining structure is 350m. In the western area, more than 20 large ore pits (2m to 12m by 1m to 2m depth) could be recognised (*fig. 7*). The chain of the ore pits follows the orientation of the copper veins in the area.

(c) The site is covered with vegetation, and no copper minerals or archaeological finds were revealed.

(d) Due to the dominance of secondary copper minerals over primary sulphides, it appears that it is a largely oxidised deposit. The secondary copper minerals malachite, azurite and possibly some copper sulphate (chalcanthite) appear disseminated and irregularly intergrown with the ore alongside hematite with a metallic hue. Shiny, yellowish sulphides, pyrite and chalcopyrite can also be identified. On the top of the site gabbros with orthopyroxene predominate.

(e) Unclear, Classical Greek and later periods.

(f) Surveys 2014, 2015.

(g) Черных 1978, 19; Лещаков et al. 2016a, 882.

3. Zidarovo, Yurta Mining Area 35T 531869 4689271

(a) The site is located 3.3km north-west from the centre of Zidarovo village, Burgas municipality, along both banks of the Yurta River (*fig. 8*), a left tributary of the Fakiyska river.

(b) Linear earthworks marking the ancient mining are located along the right bank of the Yurta river. The terrain is significantly lowered by modern mining that destroyed a large part of the ancient works visible until the 1970ies (*fig. 9*). Back then, on an area of more than 1km^2 at least 32 ancient open mine pits were registered. The largest among them was 250m long and from 3m to 10m wide. Fragments of vessels made on potter's wheel can be found along the right bank of the Yurta river.

(c) Scattered pieces of metallurgical slag are found on the surface.



Fig. 8. Location of a section of the ancient mining area Yurta, Zidarovo.

(e) Unclear, Classical Greek and later periods.
(f) Surveys 2014, 2015.
(g) Черных 1978, 24 f.; Русков 2011.

4. Kayata, Fortress with Settlement
35T 533699 4690704 (Fortress)
35T 533595 4690911 (Settlement)

(a) The site is located 4.3km north-east from the centre of Zidarovo village, Sozopol municipality. The fortress covers a low hill on the left bank of the Fakiyska river. A suburban settlement is located on the first terrace on the western side of the river at the foot of the hill (*fig. 10*).
(b) The fortress covers an area of almost 0.3ha. It is marked by sectors of stone walls made of rough stone blocks bound with white mortar as well as by isolated stone clusters from destroyed walls. The area of the fortress is heavily overgrown therefore it is not possible to trace the fortification structures and the remains of the buildings as a whole. Isolated sherds from vessels made on a fast turning potter's wheel appear inside the fortress. The settlement below the fortress is located on arable land. Concentrations of pottery fragments, architectural ceramics and stray pieces of secondary-baked wall plaster are found on the surface (*fig. 11*). Some of the handmade pottery and others produced on a



Fig. 9. Mining zone Yurta, Zidarovo from the north-west.



Fig. 10. Fortress and satellite settlement Zidarovo-Kayata, view from the west.



Fig. 11. Pottery from the settlement at Zidarovo-Kayata.



Fig. 12. Izvor fortress from the north.



Fig. 14. Izvor fortress, detail of destroyed northern wall.

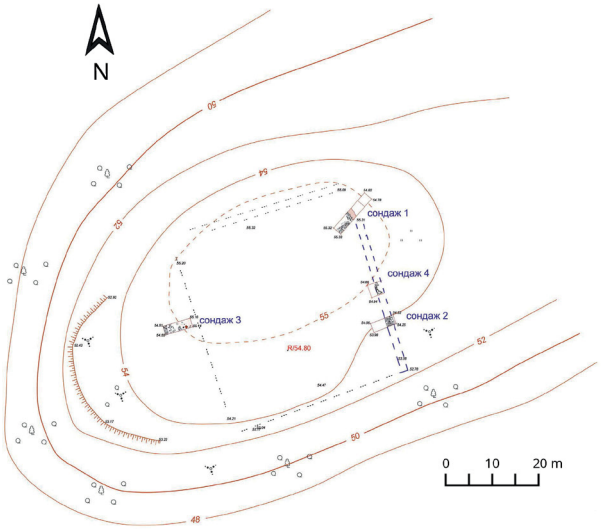

Fig. 13. Map of Izvor fortress with excavated sections in 2017 (after Гюрджийска/Иванов 2018, обр. 1).



Fig. 15. Section of stone fortification wall at Izvor fortress (after Гюрджийска/Иванов 2018, обр. 3).



Fig. 16. Late Hellenistic pottery from Izvor fortress.



Fig. 17. Architectural terracotta from Izvor fortress.

potter's wheel belong to the Late Iron Age (Classical Antiquity). Fragments of amphorae also appear. Pottery fragments of vessels dating from the Middle Ages (11th to 12th cent. AD) made on a fast turning potter's wheel were also found. The medieval settlement was probably related to the fortress.

(e) Classical Greek period, Middle Ages.

(f) Survey 2015.

(g) Делирадев 1953, 85; Делев 1990, 141; Лещаков et al. 2016a, 880.

5. Fortress 'Kaleto' Izvor 35T 538539 4690044 (Fortress)

(a) The fortress is located 1.05km north-east from the centre of Izvor village, Burgas municipality. It is located at an altitude of 55m above sea level on top of the flat ridge of a low hill (*fig. 12*) on the right bank of the Izvorska river and covers an area of 0.18ha. A deep ravine surrounds the terrain from the south and the south-east. The natural access to the fortress is from east/north-east.

(b) The fortress wall follows the configuration of the flat ridge and is made of rough stone blocks as a dry masonry. The fortified area is of an irregular rectangular plan and covers about 0.2ha (*fig. 13*). Numerous treasure hunters' pits up to 0.5m deep and reaching the basement rock were observed inside the fortress (*fig. 14–15*). The cultural layer is 0.3m to 0.4m thick. The soil left from the treasure hunters' trenches contain a large amount of pottery sherds, amphorae fragments and architectural terracotta dating from the Late Hellenistic period: tegulae (solenes) and imbrices (kalupter), pithoi, and handles of amphorae of pseudo-Kos type (*fig. 16–17*). The fortification near Izvor village is similar to the ones explored near Sinemorets village and Primorsko town (Pharmakida).

(e) Late Hellenistic period (2nd to 1st cent. BC).

(f) Surveys 2014, 2015, 2017.

(g) Лещаков et al. 2016a, 880; Гюрджийска/Иванов 2018, 116–119.

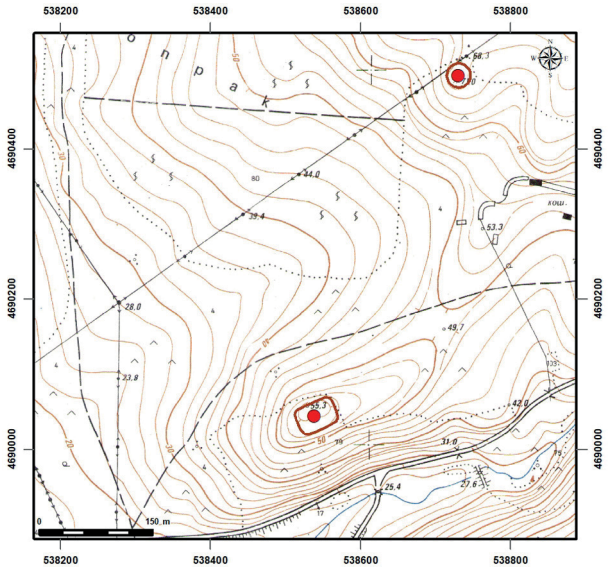

Fig. 18. Location of the Hellenistic fortress at Izvor and the burial mound (cat. no. 6).



Fig. 19. Burial mound Izvor from the south-west.

6. Burial Mound Izvor 35T 538731 4690497 (Tumulus)

(a) The tumulus is located in the Drenaka site, 1.55km north-east from the centre of Izvor village, Burgas municipality. It rises on the higher sector of a slope facing south 71m above sea level and 490m north-east of the Late Hellenistic fortress of Izvor (*fig. 18–19*).

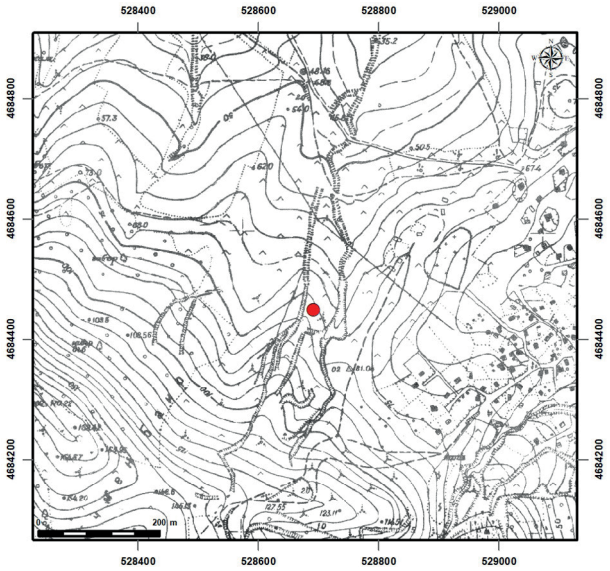

Fig. 20. Location and traces of ancient mining west from the village of Gabar.



Fig. 21. Traces of ancient mining next to the village of Gabar, view from the north.

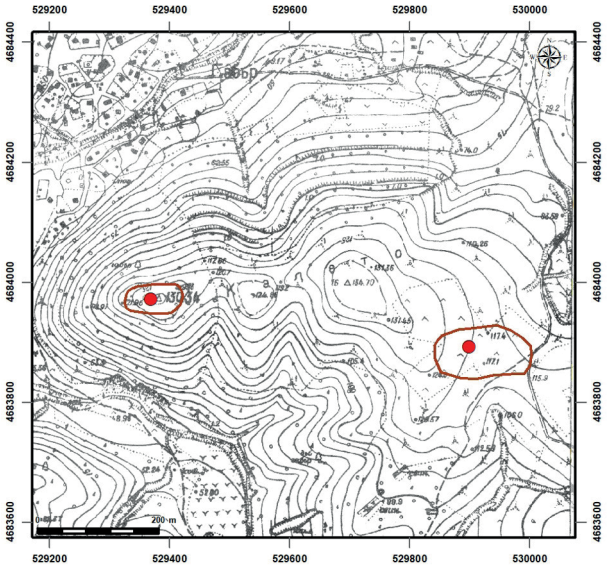

Fig. 22. Location of Kaleto fortress (left) and satellite settlement (right) next to the village of Gabar.

b) The tumulus is ca. 40m in diameter and 4.5m in height. It has been cut by two old linear treasure hunter's trenches with a visible depth of about 3m. There is no evidence of a destroyed burial structure, and no archaeological artefacts are to be found. The tumulus is probably associated with the fortress as the two are visually linked and are in close proximity.
(e) Probably Late Hellenistic period.
(f) Survey 2015.
(g) Лещаков et al. 2016a, 879.

7. 'Mining Site' Echmen Bair 35T 528693 4684449

(a) The site is located 500m west from the centre of Gabar village, Sozopol municipality extending over the north slope of Echmen Bair height, between 40m and 130m above sea level (*fig. 20*).
(b) Some small eroded sherds of handmade pottery were found in the lower sector of the central mine.
(c) The traces of mining activities are oriented north/south. Three main structures were registered, with a total length of 450m, 2m to 5m width and 1m to 1.5m depth (*fig. 21*). No ore was found during the surveys.
(e) Unclear.
(f) Surveys 2014, 2015.
(g) Лещаков et al. 2015a, 851.

8. Kaleto Fortress 35T 529370 4683971

(a) The site is located 440m south-west from the centre of Gabar village, Sozopol municipality, situated on the westernmost sector of Kaleto height, 130m above sea level.
(b) The fortress covers 0.4ha of a naturally fortified peak (*fig. 22–23*). The walls are constructed of rough stone blocks fixed with white mortar. Certain sections of the wall are preserved up to 1.5m height. The interior is densely covered with bushes. The stone wall and the fortified territory are damaged by many treasure hunter's ditches (*fig. 24–25*). The soil contains architectural terracotta and sherds of vessels made on a potter's wheel.



Fig. 23. Kaleto fortress, next to the village of Gabar, from the east.



Fig. 24. Modern destruction of the eastern fortification wall of Kaleto fortress, next to the village of Gabar.

(c) According to local residents in the past, clusters of slag and other traces of metallurgical and/or metalworking activity were found.
(e) Middle Ages (10th to 11th cent. AD).
(f) Surveys 2014, 2015.
(g) Шкорпил 1885, 44; Делирадев 1953, 82; Делев 1990, 141; Лещаков et al. 2015a, 851.

9. Settlement at the Foot of the Kaleto Fortress
35T 529900 4683892

(a) The village is situated 1680m south-east from the centre of Gabar village, Sozopol municipality, on the east slope of Kaleto height, 115m to 125m above sea level.
(b) The settlement area covers ca. 1.2ha and is entirely used for agriculture (*fig. 22, 26*). Numerous archaeological artefacts appear on the surface mostly fragments of wheel-made pottery. Fragments of a couple of glass bracelets, an iron pruning knife and a stone spindle whorl were found (*fig. 27–29*). On the terrain some buildings can be recognised by stone accumulations.
(e) Middle Ages (10th to 11th cent. AD).
(f) Surveys 2014, 2015.
(g) Лещаков et al. 2015a, 851.

10. Burial Site Echmen Bair
35T 528491 4683853

(a) The burial site is situated 930m south-west from the centre of Gabar village, Sozopol



Fig. 25. Segment of the inner side of the fortification wall at Kaleto fortress.



Fig. 26. Satellite settlement next to Kaleto fortress, view from the east.

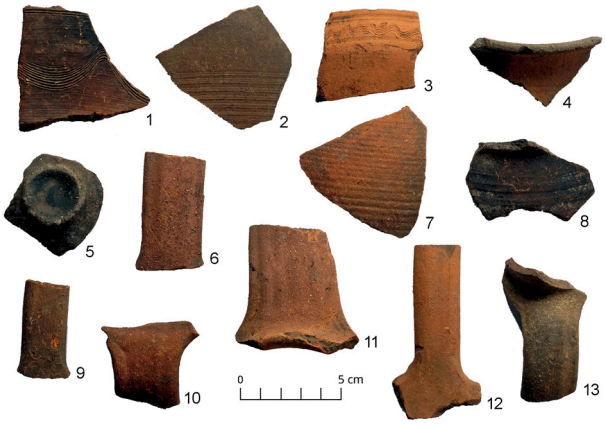

Fig. 27. Pottery from the satellite settlement next to Kaleto fortress.



Fig. 28. Iron sickle from the satellite settlement next to Kaleto fortress.



Fig. 29. Stone spindle whorl from the satellite settlement next to Kaleto fortress.

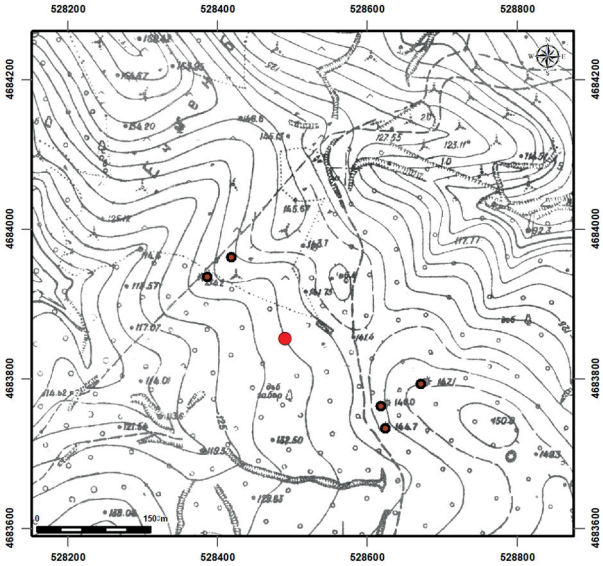

Fig. 30. Location of the Echmen Bair burial site.



Fig. 31. Burial mound from the Echmen Bair burial site.



Fig. 32. Central burial mound at the Gorniya Aikan burial site.



Fig. 33. Modern destructions at the south-western burial mound at Gorniya Aikan burial site.

municipality, on the higher sector of Echmen Bair height, in a wooded area, 134m to 150m above sea level.

(b) The burial site comprises two groups of tumuli about 300m away from each other (*fig. 30*). The north-west group consists of two tumuli, the first one 20m in diameter and 2m of height (*fig. 31*), and the second one 14m in diameter and 0.6m high. The south-east group is formed by three tumuli. The first one is 12m in diameter and 0.5m in height, the second one 15m in diameter and 0.6m to 0.8m high, and the third one 12m in diameter and 0.6m high. Some of the mounds are disturbed by treasure hunter's diggings. No archaeological material was found on site surveys.

(e) Unclear, Iron Age or Roman period.

(f) Survey 2014.

(g) Лещаков et al. 2015a, 851.



Fig. 34. Southern mound at the Tsigansko Grobe burial site.



Fig. 35. Modern destruction at the northern mound at Tsigansko Grobe burial site.

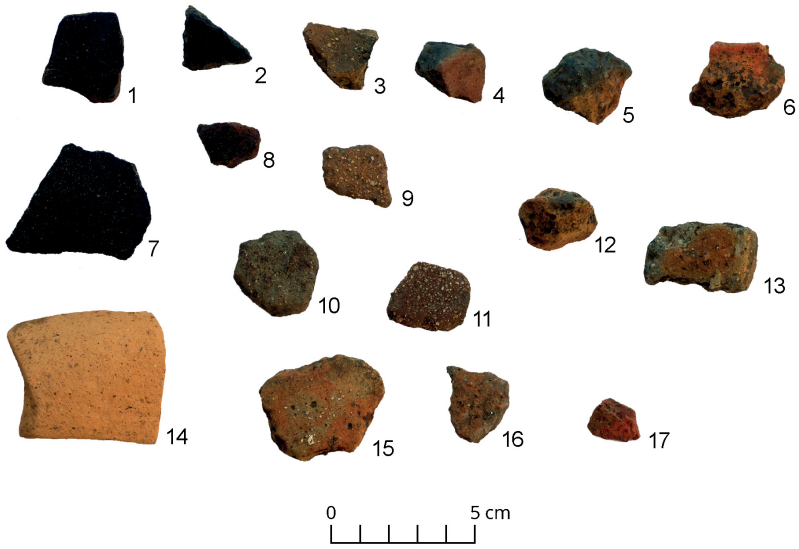

Fig. 36. Pottery fragments from the modern destruction at the northern mound at the Tsigansko Grobe burial site.

11. Burial Site Gorniya Aikan 35T 528780 4682902

(a) The burial site is situated 1540m south-west from the centre of Gabar village, Sozopol municipality, on the middle sector of a wooded slope facing east, between 141m and 144m above sea level.
(b) The burial site consists of three burial mounds arranged in a line, oriented north-east/south-west. The central tumulus is the largest one: 30m in diameter and 3m in height (*fig. 32*); the south-west one is 10m in diameter and 0.6m high; and the north-east one 20m in diameter and 1.2m high. All tumuli are damaged by treasure hunter's diggings (*fig. 33*). The mounds consist of piled-up earth. A couple of fragments of handmade and wheel-made pottery were found in one of the treasure hunter's ditches.
(e) Unclear, Iron Age or Roman period.
(f) Survey 2014.
(g) Лещаков et al. 2015a, 851.

12. Burial Site Tsigansko Grobe 35T 530697 4684817

(a) The burial site is located 1540m north-east from the centre of Gabar village, Sozopol municipality, situated on arable land in the middle sector of a slope facing north, between 80m and 83m above sea level.
(b) The burial site comprises two tumuli rising next to each other. The southern one is larger, 25m in diameter and 3m in height, made predominantly of earth (*fig. 34*). Dispersed large rough stone blocks were registered at its base on the north side. The smaller tumulus is almost entirely destroyed by digging with a machine and its shape and initial size cannot be determined (*fig. 35*). The remains of the mound contain tiny fragments of handmade pottery and secondarily fired fragments of clay daub (*fig. 36*).
(e) Unclear, Iron Age.
(f) Survey 2015.

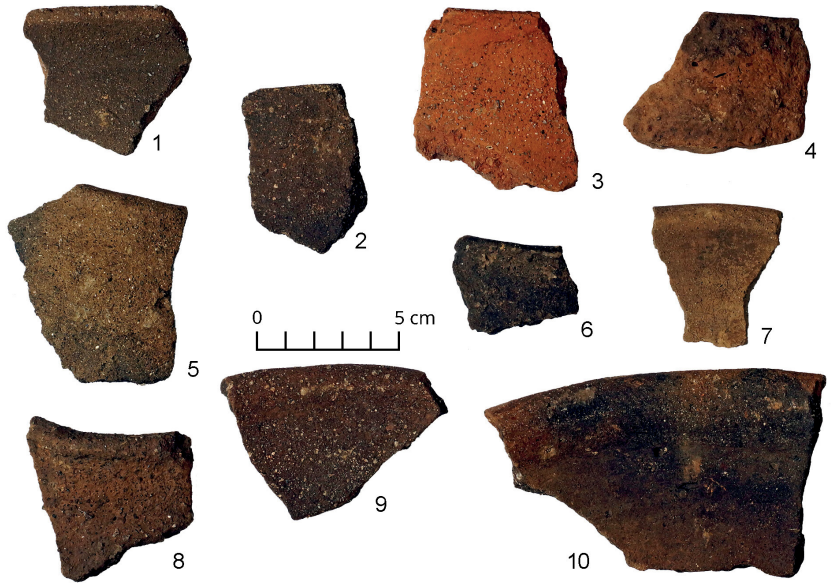

Fig. 37. Late Neolithic pottery from prehistoric site Stublitsa.



Fig. 38. Prehistoric site Stublitsa, view from the south.

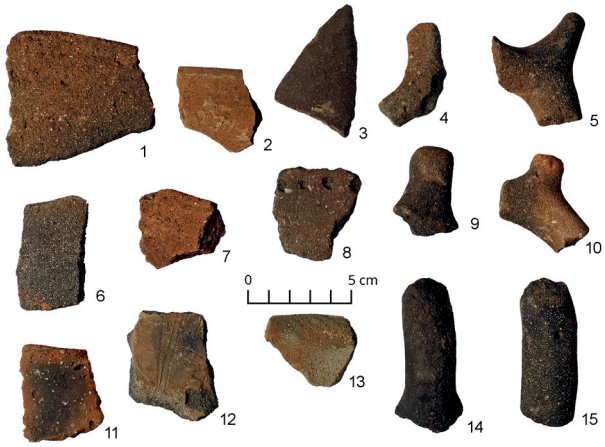

Fig. 39. Late Neolithic pottery from prehistoric site Stublitsa.



Fig. 40. Stone tools from the prehistoric site Stublitsa.

13. Settlement Stublitsa 35T 525136 4685610

(a) The settlement is located 4240m north-west from the centre of Gabar village, Sozopol municipality. It covers the lower sector (120m to 140m above sea level) of a slope facing north, enclosed by two ravines (*fig. 38*). The site is situated on arable land. An asphalt road runs through the village's southern part. The Stublitsa Spring is 80m south further up the slope.

(b) The archaeological artefacts are to be found in an area of 2.4ha and of irregular oval shape. Numerous fragments of prehistoric handmade pottery (*fig. 37*, *39*) as well as numerous stone tools – hammers, adzes, semi-finished adzes, and querns – are visible on the ground (*fig. 40–41*). Scattered concentrations of secondarily fired clay daub marking houses have also been observed. Some scattered fragments of pottery made on a potter's wheel also appear among the prehistoric artefacts.

(e) Late Neolithic, Roman period.

(f) Survey 2015.

(g) Лещаков et al. 2016a, 879.



Fig. 41. Stone adzes and axes from the prehistoric site Stublitsa.

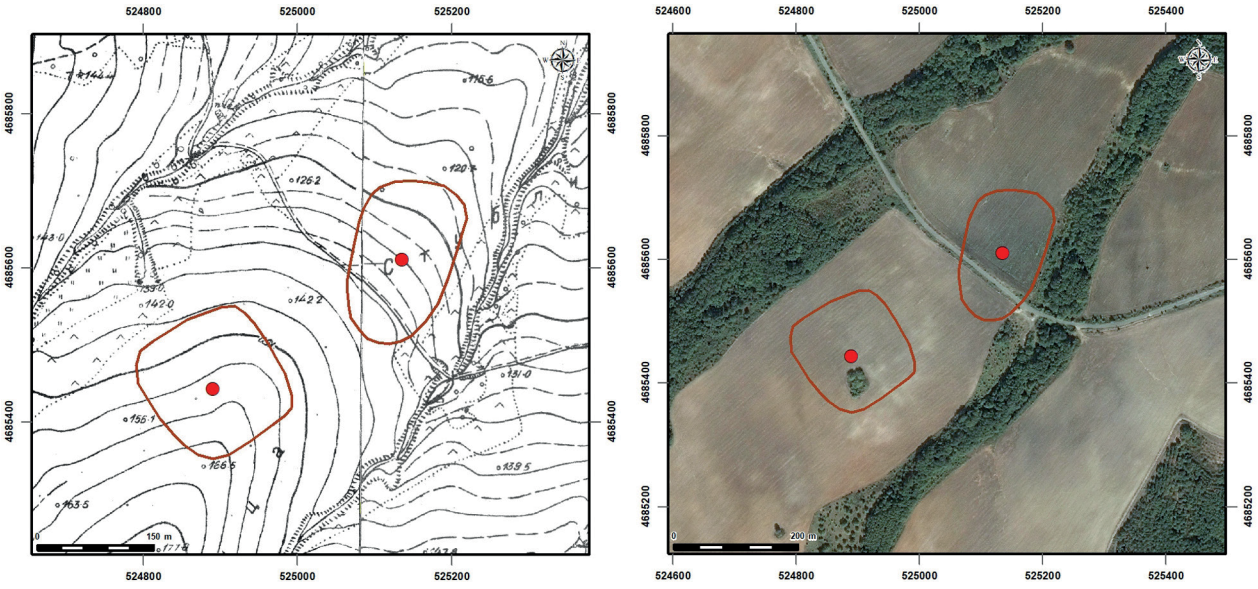

Fig. 42. Location of prehistoric (left) and antique (right) sites at Stublitsa.

14. Stublitsa Antique Site 35T 524891 4685443

(a) The site is located 4490m north-west from the centre of Gabar village, Sozopol municipality. It covers the middle sector of a slope facing north (*fig. 42–43*), 145m to 166m above sea level. The Stublitsa Spring is 140m east of the site's periphery. (b) Archaeological artefacts are found on an area of 2.6ha of arable land. A concentration of large and mid-sized rough stone blocks marking walls has been observed in the south corner of the site



Fig. 43. Antique site Stublitsa, view from the north.



Fig. 44. Hellenistic and Roman materials from the antique site Stublitsa.



Fig. 45. Pottery and metallic slags from the Bakar Bokluk metallurgical site.

on a rectangular area of 0.15ha. The stones are in a heavily overgrown and uncultivated terrain which prevents a more precise classification of the structures. However, it is probably a complex of antique buildings with stone walls. Concentrations of household and architectural ceramics and fragments of pithoi were registered in the arable part of the site (*fig. 44*).

(e) Roman period; 2nd to 4th cent. AD.
(f) Survey 2015.
(g) Лещаков et al. 2016a, 879 f.

15. Metallurgical Site Bakar Bokluk 35T 539312 4679010

(a) The site is located 1480m south-west from the centre of Krushevets village, Sozopol municipality at an altitude of 140m to 175m above sea level along the northern bank of a shallow ravine with a spring which is a right tributary of the Izvorska River.
(b) Scattered pieces of black metallurgical slag and sherds of vessels made on the potter's wheel appear along the ravine and inside the flow bed (*fig. 45*). A tumulus-like elevation rises at the westernmost end of the site, overgrown with vegetation. It is 4m to 5m in height. There are sherds of vessels and amphorae in the riverbed.
(c) The surface of the site is tightly covered with large pieces of slag. This accumulation might be explained as waste from metallurgical processing from a workshop located on the river bank (*fig. 46*).
(e) Late Iron Age, Roman or early Byzantine.
(f) Survey 2014.
(g) Георгиев 1987, 38 f.; Делев 1990, 142; Лещаков et al. 2015a, 851.

16. Fortress Krushevets Kaleto 35T 538707 4681487

(a) The site is located 1760m north-west from the centre of Krushevets village, Sozopol municipality on a low elevation with steep slopes along the right bank of the Izvorska River (*fig. 47*), 157m to 161m above sea level. The natural access is from north-east by a low saddle. The river surrounds the hill from the south and west, and deep ravines come from the north-east and north-west.

(b) The flat upper part of the peak is surrounded by piles of rough stone blocks marking the track of the fortress walls (*fig. 48*). Pieces of white mortar appear among the stones. The fortified area is 0.4ha and has an irregularly round plan. A large pile of stones, probably from destroyed towers or bastions, were observed in front of the west sector of the wall. The entrance of the fortress is from east/north-east. The cultural layer in the interior is thin and the basement rock is visible at many spots. There are no treasure hunter's diggings and archaeological artefacts were not recorded.
(e) Unclear, early Byzantine or later periods.
(f) Survey 2014.
(g) Делирадев 1953, 86; Делев 1990, 142.

17. Burial Site Chokanov Egrek 35T 539446 4682463

(a) The tumulus field is located 2200m north-west of Krushevets village, Sozopol municipality, on a low ridge in a hilly terrain, 205m to 206m above sea level.
(b) The burial ground consists of two tumuli along a line oriented east/west, about 300m from each other. The eastern mound is 30m in diameter and 1.5m in height. It is damaged by a couple of treasure hunter's trenches (*fig. 49*). The mound is built of earth and stones. The western tumulus is 15m in diameter and 1m high. The surface of both mounds is heavily overgrown with shrubs and trees. Archaeological artefacts were not discovered.
(e) Unclear.
(f) Survey 2014.



Fig. 46. Tumulus-like height at the western part of the Bakar Bokluk site.



Fig. 47. Kaleto Krushevets fortress, view from the south-east.



Fig. 48. Course of the fortification wall.

18. Metallurgical Site Atia 35T 548814 4697882

(a) The site is located 1150m north-east of the square in the Rosen mining village and 4000m south-west from the centre of Chernomorets town. It lies 30m and 70m above sea level, on a terrace slightly sloping to the north/north-west at the foot of Zarbuzan height, close to the new tailing pond of the Rosen mine (*fig. 50*).
(b) Pottery fragments from handmade vessels and others made on a potter's wheel, some of them black glazed or with red varnish appear along the borders of the site (*fig. 52*). Amphora fragments were also discovered as well as architectural terracotta. Dense accumulations of small pieces of slag, alternating with layers of ash and coal were observed on the surface and in modern trenches in the central-southern part and along the southern periphery of the site. The site was severely affected by the construction of the new tailing pond of the Rosen mine. Nakov published two ^{14}C dates from charcoal collected from slags: 2291±40 BP



Fig. 49. Chokanov Egrek, eastern burial mound with modern destructions.



Fig. 50. Metallurgical site Atiya, view from the south.



Fig. 51. Consolidated blocks of metallurgical slag.



Fig. 52. Fragments of hand and wheel made ceramic vessels, some of them black glazed or red varnish, as well as ceramic building materials from Atiya.

(460-180 calBC [2σ]); 2096±40 BP (240-0 calBC [2σ]).[1]

(c) Remains of metallurgical activity – slag, pieces of copper ore, and clay fragments of destroyed metallurgical furnaces – are scattered over an area of ca. 7.0ha. The slag can be classified into two main types: with traces of oxidised copper and with high iron content. In the north-west part of the site, two blocks up to 2m^2 of porous consolidated slag with high iron content were registered (*fig. 51*). In the 1970ies, more than 10,000t of old metallurgical slag were extracted from the same site.

(e) Iron Age, Classical Greek, Roman and early Byzantine periods.

(f) Surveys 2010, 2015.

(g) Черных 1978, 20–22; Наков/Шарп 2008, 115. f.; Лещаков/Класнаков 2011, 584; Лещаков et al. 2016c, 937–941; Цанкова et al. 2016, 62–66.

1 R. Nakov informs that the dating has been carried out in the University of Arizona but the dates are published without lab codes. The calibration was made with CalPal 2014 on the INTCAL 13 calibration curve.



Fig. 53. Prehistoric site Garmitsa, view from the south-east.



Fig. 54. Late Neolithic pottery fragments from prehistoric site Garmitsa.

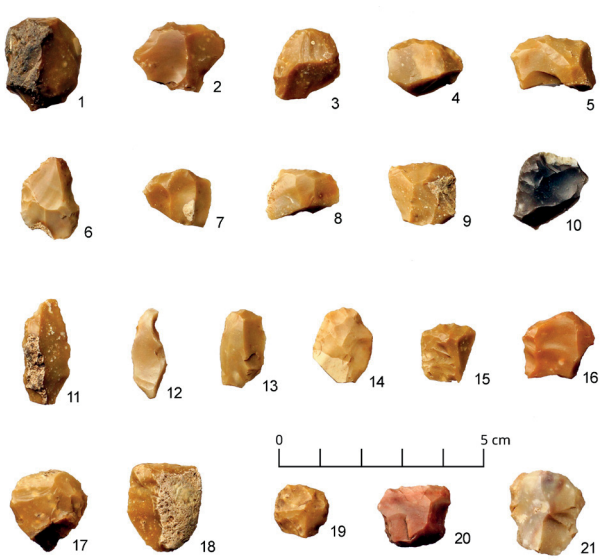

Fig. 55. Chipped stone artefacts from the Late Neolithic site Garmitsa.

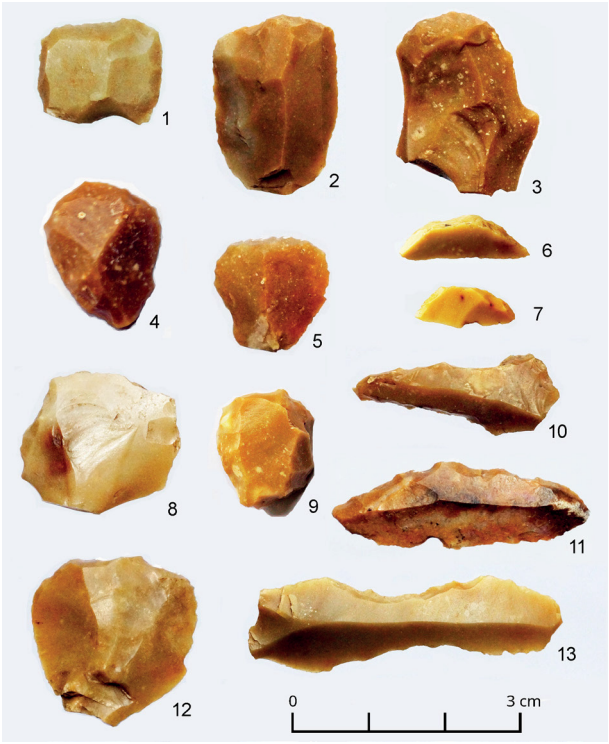

Fig. 56. Chipped stone artefacts from the Late Neolithic site Garmitsa.

19. Prehistoric Settlement Garmitsa 35T 550451 4697477

(a) The site is located 2790m south-west from the centre of Chernomorets town, Sozopol municipality. It lies on an arable land on the ridge and the slopes of a low hill facing east/south-east, 52m to 68m above sea level (*fig. 53*).

(b) A high concentration of archaeological artefacts was observed in the highest sector of the hill and along its east and south-east slopes: fragments of hand-made pottery (*fig. 54*), flint and stone tools. Among the stone tools, there are also semi-finished objects (*fig. 55–56*) suggesting on-site production. Large pieces of secondarily fired clay wall plaster were found in an old trench on the ridge of the hill. Along the south-west slope of the hill two spots with a concentration of secondarily fired daub were registered probably marking houses destroyed by agricultural works.

(d) On the territory of the site a dozen of pieces of specularite (grey hematite) were found. One of the ore fragments displays also copper mineralisation (*fig. 57*).

(e) Late Neolithic.

(f) Surveys 2010, 2013, 2015.

(g) Klasnakov 2010, 13 f.; Leshtakov 2011, 132 f.; Лещаков/Зидаров 2014, 70–73; Лещаков 2014, 653 f.

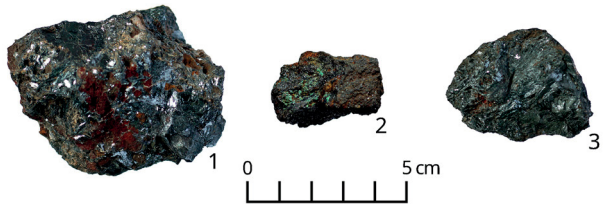

Fig. 57. Pieces of ore from prehistoric site Garmitsa.



Fig. 58. Burial mound Garmitsa, view from the south.

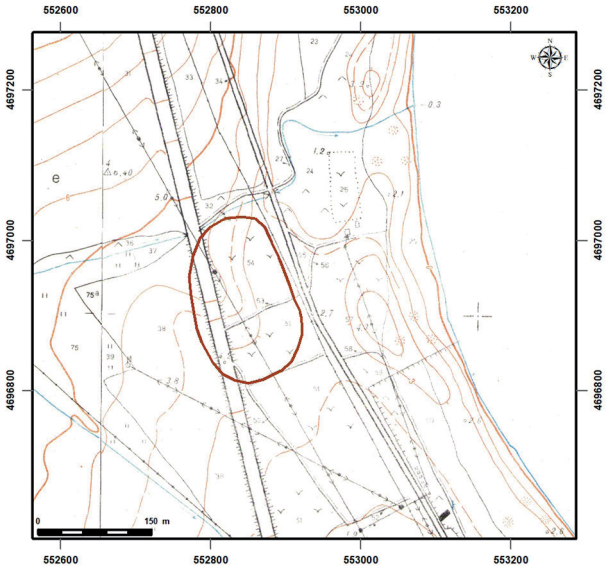

Fig. 59. Location of the prehistoric site Akladi Cheiri.

20. Garmitsa Burial Mound 35T 550612 4697784

(a) The tumulus is located 2470m south-west from the centre of Chernomorets town, Sozopol municipality in the north-east periphery of a plateau-like elevation with good views from all sides, 61m to 67m above sea level.
(b) The tumulus is 46m in diameter at the base and 5.5m high (*fig. 58*). It is the largest tumulus north of Apollonia Pontica. Middle-size rough stone blocks appear along its southern periphery. Its central sector is destroyed by an old treasure hunter's ditch.
(e) Classical Greek or Roman periods.
(f) Surveys 2010, 2013, 2015.
(g) Панайотова/Тонков 2013, 225–227.

21. Prehistoric Site Akladi Cheiri 35T 552864 4696861

(a) The site is located 2490m south from the centre of Chernomorets town, Sozopol municipality on a low and flat seashore about 250m away from the contemporary coastline, on the boundary between sand dunes and arable land (*fig. 59*) 1m to 4m above sea level. The site is situated ca. 2.5km to 3km east/north-east of the first low heights of Medni Rid (*fig. 60*).
(b) 70 dug-in structures were excavated containing artefacts from the Late Neolithic to the Early Bronze Age; remains of two houses; as well as many thermal structures (*fig. 61–62*, investigated areas in 2008 and 2009). Three burials were also discovered within the area studied, dating



Fig. 60. Prehistoric site Akladi Cheiri, view from Medni Rid.



Fig. 61. Akladi Cheiri. Rescue excavations in 2008.



Fig. 62. Akladi Cheiri. View on the eastern section of the excavated area with several pit features after a heavy rainfall.

from the 4th mill. BC, and in addition two soldiers' graves probably from the 19th cent. AD.

(c) Clear traces of metallurgical activities carried out on the site were registered: pieces of copper ore, pottery fragments with metallurgical slag on them, metallurgical crucibles and structures and copper tools were found (*fig. 63*). Pieces of copper and iron ore occurred within the context of archaeological structures from the Late Neolithic and the Chalcolithic. From the pit and grave contexts, there is a series of nine radiocarbon dates (Tsirtsoni 2016, 51). From pit 173a an additional date is available: MAMS-35509: 5571±25 BP (4454-4356 calBC [2σ]).

(e) Late Neolithic, Chalcolithic, transitional period, Early Bronze Age.

(f) Partially explored during archaeological rescue excavations in 2008 and 2009.

(g) Klasnakov 2010, 13; Лещаков et al. 2009, 74–77; Лещаков 2010, 175 f.; Лещаков/Класнаков 2010, 58–61; Leshtakov 2010, 735 f.; 2011; 2013, 35–54; Rehren et al. 2016, 205–214.

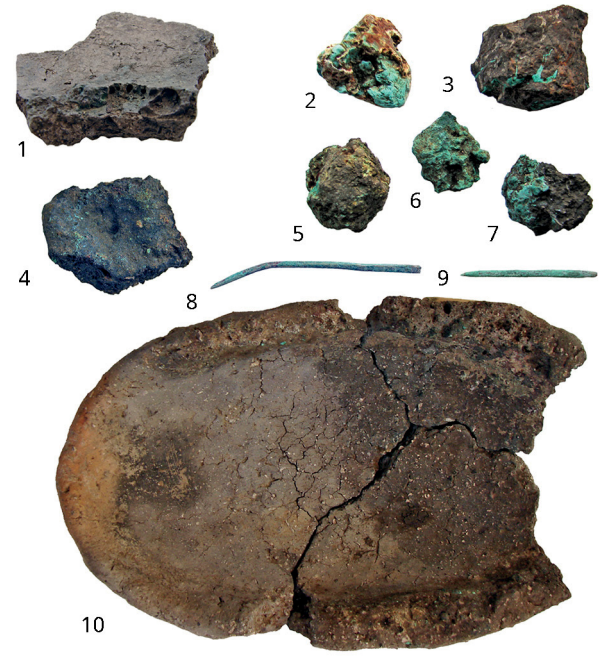

Fig. 63. Archaeometallurgical finds from the prehistoric site Akladi Cheiri (different scale, cf. Kunze/Pernicka, this volume, 387–414, fig. 3–4.

22. Dimitriev Yurt
35T 550104 4696800

(a) The site is located 3520m south-west from the centre of Chernomorets town, Sozopol municipality at the foot of the Stamov Bair hill, on the left bank of a shallow ravine over a plateau-like terrace facing south-east, east and north-east, 75m to 110m above sea level (*fig. 64*). A small part of the



Fig. 64. Dimitriev Yurt site, view from the south.

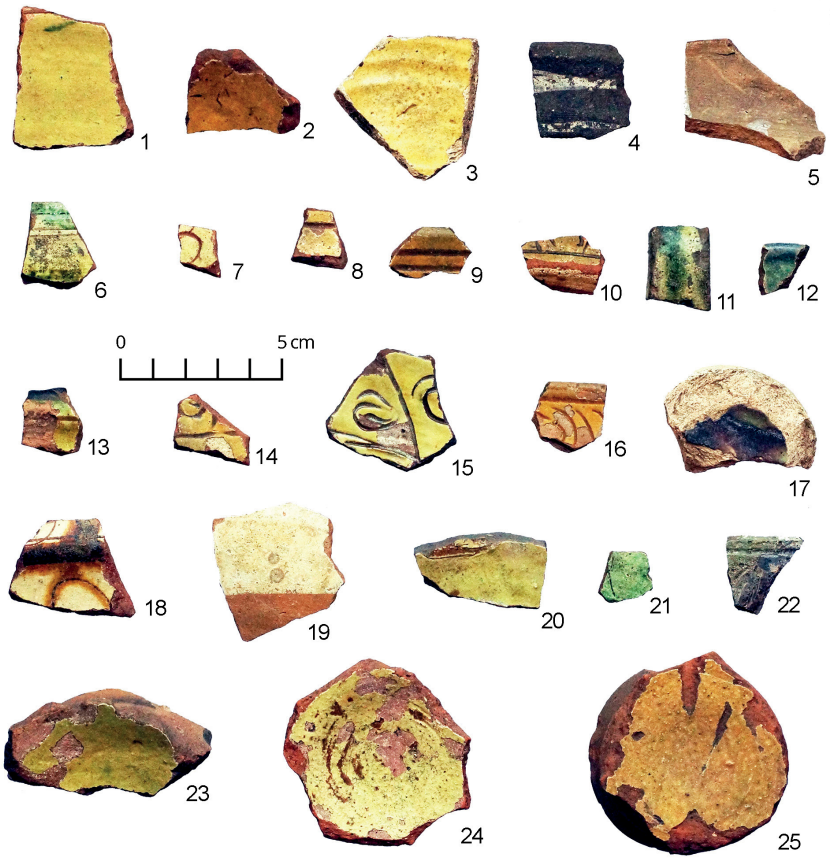

Fig. 65. Late Medieval pottery fragments from the Dimitriev Yurt site.

site is in overgrown terrain, and the larger one is destroyed.
(b) Pottery fragments and architectural ceramics (*fig. 65*) appear over an area of 9.3ha. The fragments of medieval sgraffito-pottery are diagnostic.
(c) Two stone hammers and a couple of pieces of slag and of iron ore were also found.
(e) Late prehistory? Late Middle Ages to early modern period (14th to 17th cent. AD).
(f) Surveys 2013, 2015.
(g) Лещаков 2014, 653.

23. Mine and Metallurgical Site Rosen 35T 547915 4696627

(a) The site is located 420m south-west of the Rosen mining village square and 5360m south-west from the centre of Chernomorets town, Sozopol municipality at the foot of Medni Rid, south-east of the Golyam Rosen Bair height, on a steep slope facing north/north-east, 98m to 140m above sea level. A contemporary asphalt road is running through the lower sector of the site.
(b) Metallurgical slag, pieces of copper ore, and a few fragments of pottery made on a potter's wheel were found around the site and in the lower sector of a heap located next to it. A fragment of a stone quern has also been discovered.
(c) Three deep ravines were observed on the terrain (the deepest one of 5m) connected with some shallower trenches. All of them form a linear opencast mine oriented north-east/south-west and about 90m long, with a maximum width of 16m (of the deepest moat) (*fig. 66*). Most likely the mine followed the ore vein. In the 20th cent. AD the lower sector of the site was covered with a thick layer of earth, and currently there is nothing to see. However, it is known that the work continued in the north-east direction to the administrative buildings of the abandoned Rosen mine. Thus, the initial length of the mine can be estimated to more than 250m in total. Eight areas of red fired clay and soil were observed in the zone of the ancient mine over the north-west heap (*fig. 67*) about 1000m² in size. They are of irregular shape and measure 0.5m to 1.5m each. The areas are located along the right slope of the deep ravine, which flanks the ancient

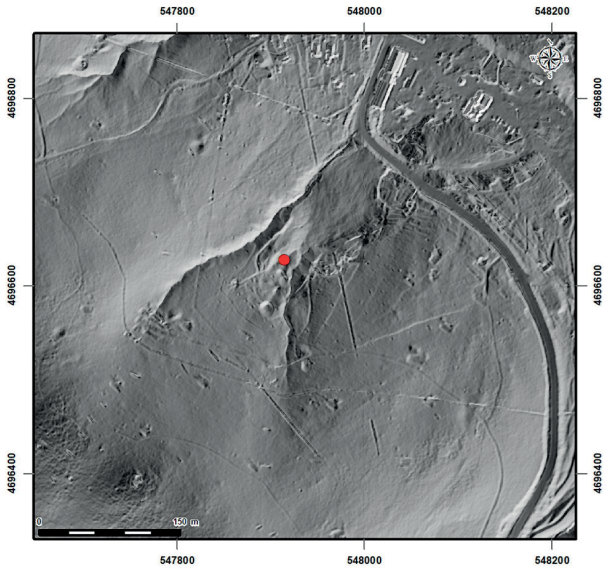

Fig. 66. Traces of ancient mining in the area of Rosen on the LiDAR record.

work from the north-west. Fragments of secondarily fired clay appear in the zone of the spots (*fig. 68*), as well as red-coloured stones bearing traces of a strong heating. The whole complex of areas with fired clay, slag, pieces of ore and other archaeological artefacts may be recognised as a platform with metallurgical furnaces for metal extraction.

(d) The occurrence of chalcopyrite, hematite, specularite and malachite from this site is known.

(e) Greek and Roman periods.

(f) Surveys 2010, 2013, 2015.

(g) Лещаков/Класнаков 2011, 582 f.; Лещаков 2014, 654; Лещаков et al. 2016c, 937–941; Цанкова et al. 2016, 62–66.

24. Golyam Rosen Bair 35T 547514 4696620

(a) The site is located 6500m south-west from the Rosen mining village square and 5700m south-west from the centre of Chernomorets town, Sozopol municipality. It extends over the ridge of Medni Rid and descends down along its south-west slope, 150m to 180m above sea level at the southern foot of the Golyam Rosen Bair peak.

(b) No archaeological artefacts were found at the site.

(c) The mining area consists of separate pits (?) (*fig. 69*) that are aligned north-east/south-west, about 200m long and from 3m or 4m to 20m wide



Fig. 67. Heap of ancient mining at Rosen.



Fig. 68. Remains of a metallurgical kiln at the heap of the ancient mine at Rosen.



Fig. 69. Traces of ancient mining in the area of Golyam Rosen Bair.

at some sectors (*fig. 70*). The waste was deposited on the north-west side of the pit's line.

(e) Unclear.

(f) Survey 2015.

(g) Лещаков et al. 2016a, 881.

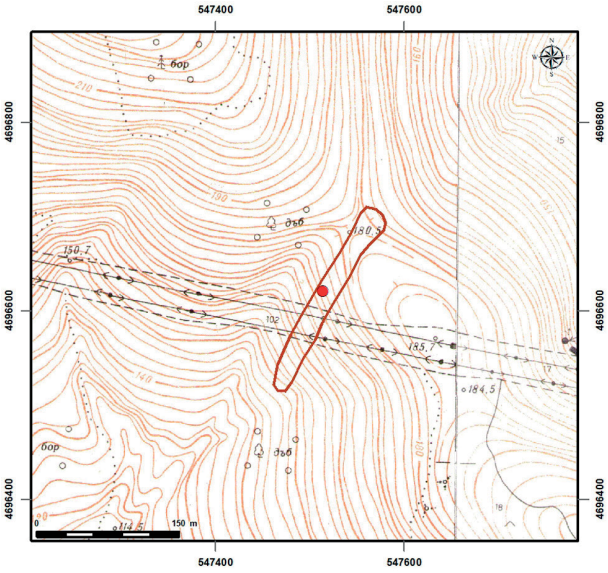

Fig. 70. Location of the traces of ancient mining in the area of Golyam Rosen Bair.

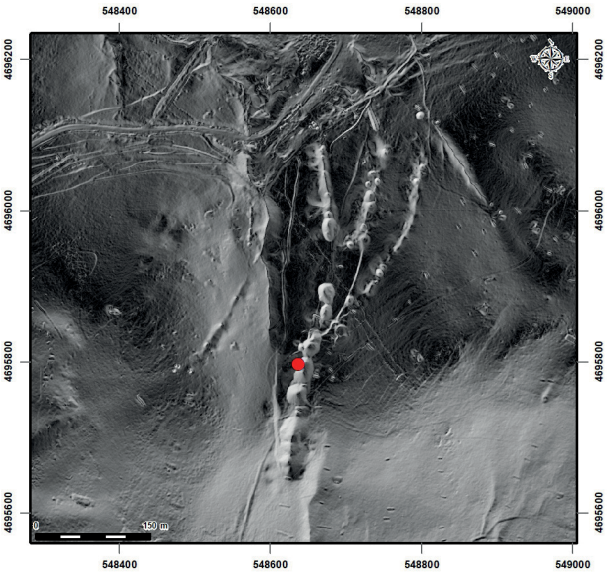

Fig. 71. Traces of ancient mining in the area of the Kyumyurlaka mine on the LiDAR record.



Fig. 72. Ancient sunken shaft in the area of the Kyumyurlaka mine.

25. Kyumyurlaka Mine
35T 548637 4695796

(a) The site is located 1400m south-east of the Rosen mining village square and 5290m south-west from the centre of Chernomorets town, Sozopol municipality on the ridge and along the north slope of Medni Rid, at the south foot of the Kyumyurlaka height 160m to 220m above sea level. The ancient works were on the territory of the Korucheshme deposit where once the industrial mine 'Stahanov' was located.
(c) A chain of trenches forms a linear mining area, oriented north-east/south-west. In its northern sector, the trenches form a tripartite structure probably following the branches of the ore vein (*fig. 71*). The total length of the mine is 470m. The width varies from a few metres to over 30m in the southern half. In depth, some of the trenches that have an irregular rectangular shape reach 25m (*fig. 72–73*). On the terrain, more frequently in the southern part of the area, copper and iron ore samples are found on the spoil heap.
(e) Unclear, Classical Greek and later periods.
(f) Surveys 2014, 2015.
(g) Черных 1978, 21; Лещаков/Класнаков 2011, 583 f.; Лещаков et al. 2016a, 881 f.

26. Kyumyurlaka Metallurgical Site
35T 548670 4695272

(a) The site is located 1840m south-east from Rosen mining village square and 5570m south-west from the centre of Chernomorets town, Sozopol municipality. It is situated on the south slope of Medni Rid between two ravines at the south-east foot of the Kyumyurlaka height, 150m to 165m above sea level. The site is about 260m south of cat. no. 24.
(b) Archaeological artefacts were found mainly in the ravines, in the beds of the small seasonal flows. A stone mortar, a fragment of a second mortar (*fig. 74*), a round stone hammer, fragments of Roman 'bricks' and stones with slag adhering to them (*fig. 75*) were found there as well as scattered fragments of wheel-made pottery. A radiocarbon date MAMS 24609: 4437±31 BP (3329–2929 calBC



Fig. 73. Traces of ancient mining at the Kyumyurlaka site.

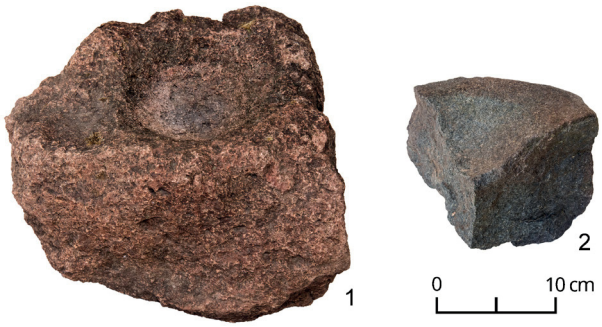

Fig. 74. Stone mortars for ore grinding from the Kyumyurlaka metallurgical site.

[2σ]) was obtained for fragments of charcoal discovered entrapped in a piece of slag (*fig. 76*). However, a second dating result from another slag from this site yielded a different age: MAMS 27894: 1765±24 BP (171–377 calAD [2σ]).[2] This could either indicate two different periods of exploitation or simply a so-called 'old wood effect'. Since the time difference is rather large the first interpretation seems more likely.

(c) In the area between both ravines, along their slopes and where they come together, piles of large pieces of slag and fragments of broken rock are to be found. The slags are dense, heavy, and dark grey to black in colour. The surfaces indicate solidification of a molten slag with a porous interior contain oxidised copper minerals. The archaeological artefacts, the slag and the large amount of rough stone blocks comprise all stages of copper production: ore crushing, ore beneficiation and metallurgical processing. The amount of slag and their type can be associated with the processing of copper sulphide ores. The bricks and stones with slag on them can be interpreted as remains of metallurgical furnaces.

(e) Late Roman to early Byzantine period.

(f) Surveys 2010, 2013, 2014, 2015.

(g) Лещаков/Класнаков 2011, 584; Лещаков 2014, 655; Лещаков et al. 2017a, 715; Цанкова et al. 2016, 61–66.

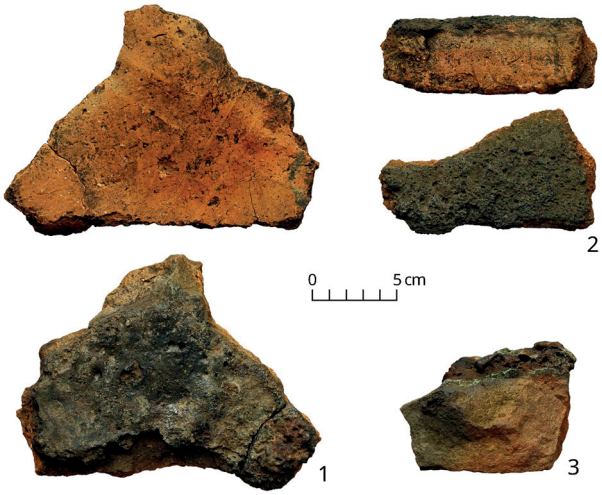

Fig. 75. Remains of metallurgical kilns with slag on the surface from the metallurgical site Kyumyurlaka: fragment of ancient tiles (1–2), unworked stone (3).



Fig. 76. Slag from the metallurgical site Kyumyurlaka.

2 The calibration was made with CalPal 2014 on the INTCAL 13 calibration curve.

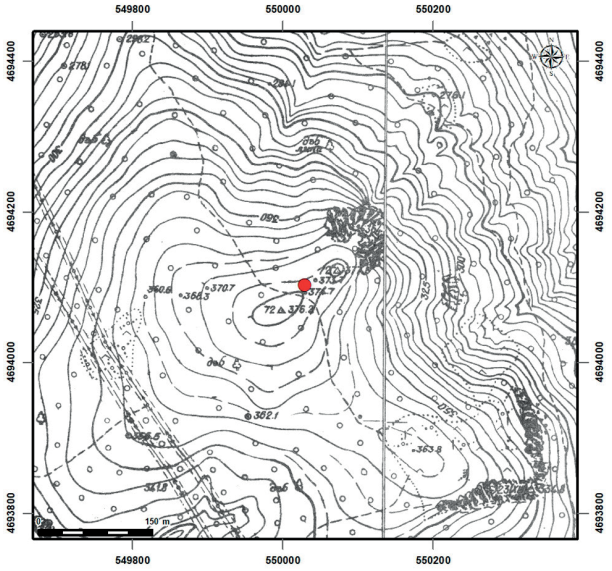

Fig. 77. Location of the Bakarlaka fortress.

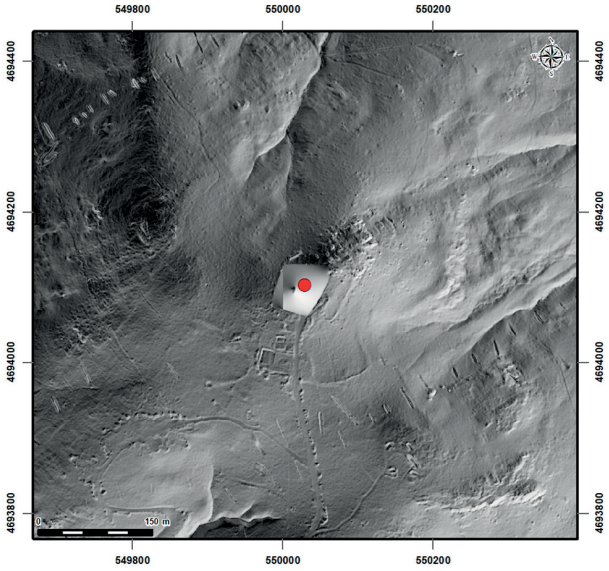

Fig. 79. Map of the Bakarlaka fortress on the LiDAR record.



Fig. 78. The Bakarlaka fortress, view from the north-east.

27. Fortress Bakarlaka 35T 550030 4694103

(a) The site is situated 5140m north-west from the centre of Ravadinovo village, Sozopol municipality. It is located on the highest point of the Medni Rid ridge, the Bakarlaka peak (*fig. 77–78*), 376m above sea level, in the area of a large modern communication installation. The north-east slopes of the peak are sheer cliff. The south and the west slopes are easier to access. A spectacular panorama opens from Bakarlaka peak in north-east, east, south-east and west direction, with sights for tens of kilometres in all directions.
(b) On the east side of the peak, there are remains of a wall about 70m long (*fig. 79*), made of mid-sized and large rough stone blocks without traces of binding material. The wall starts at the rocky sector below the north-east side of the peak, curving at its other end in the north-west direction. After this change of track, the wall is not visible and probably destroyed in recent times when the communication centre at the top was constructed. Probably the first fortress was of an irregular rectangular plan enclosing an area of not less than 0.5ha. South-east from the preserved part of the fortress there is a second linear accumulation of stones forming a wall with an L-shaped track and a length of 100m of the south segment and more than 30m of the east segment. The visible height of the wall remains is 0.5m (*fig. 80*). Contemporary trenches south-west of the fortress reveal fragments of pottery made on a potter's wheel, including some black-glazed sherds (*fig. 81*).
(e) Iron Age, Roman, Byzantine, Medieval periods.
(f) Survey 2015.
(g) Венедиков/Фол 1976, 156; Делев 1990, 144; Делирадев 1953, 88.

28. Bakarlaka Mine and Metallurgical Site 35T 549639 4694818

(a) The site is located 3670m north-east from the centre of Rosen village, Sozopol municipality. It extends from 180m to 225m above sea level, on the ridge of Medni Rid, at the northern foot of its highest peak Bakarlaka on the saddle between it and the Golite Bairi peak (*fig. 82*).
(b) Pottery fragments of wheel-made pottery appear in the zone of the mines, including a single black-glazed sherd.



Fig. 80. Section of a stone wall at the south-eastern foothill of the Bakarlaka fortress.



Fig. 81. Pottery fragments from the south-western slope of the Bakarlaka fortress.

(c) Some traces of mining activities traces of linear shape and north-east/south-west orientation were observed on the saddle and along the northern slope of the Medni Rid heights (*fig. 83*). The northern mine is about 70m long and up to 18m wide. In its southern sector pieces of black dense metallurgical slag appear on the heap. The second large mine, south-east of the first one, is about 250m long in total. It comprises several deeper trenches connected with some shallower ones (*fig. 84*). The maximum width of this structure reaches up to 15m. The next large ditch, located south-east of the previous one, is 130m long and up to 10m wide. The waste material of this structure is on the side of the slope from the north-west.
(d) Secondary copper minerals and iron minerals from the oxide zone are present.
(e) Late Iron Age and perhaps later periods.
(f) Surveys 2010, 2014, 2015, 2016.
(g) Черных 1978, 22; Лещаков/Класнаков 2011, 583.

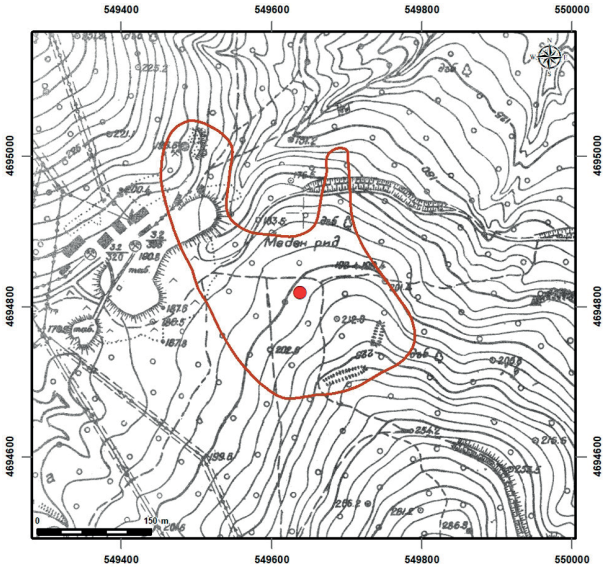

Fig. 82. Location of ancient mine and metallurgical site Bakarlaka.

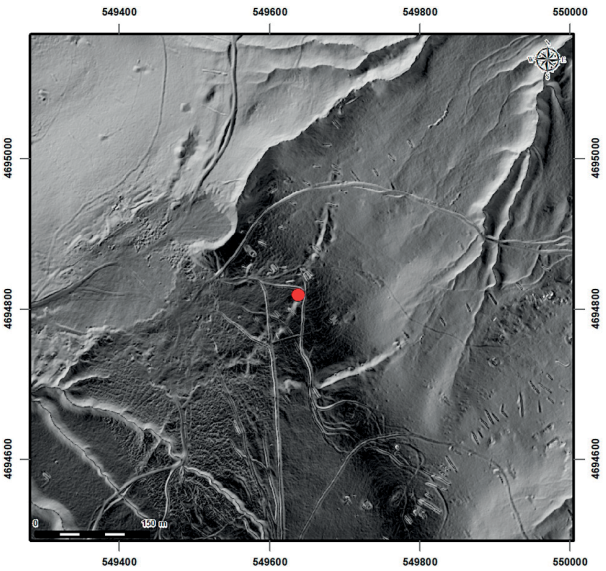

Fig. 83. Traces of ancient mining in the area of Bakarlaka on the LiDAR record.



Fig. 84. Ancient mine in the vicinity of Bakarlaka, view from the south-east.

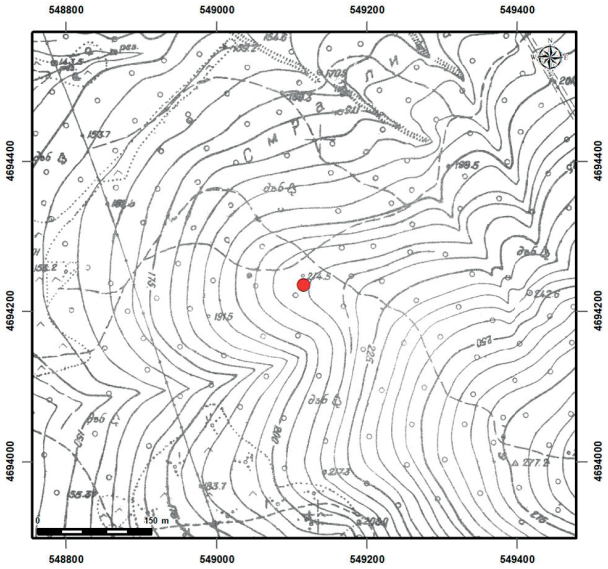

Fig. 85. Location of a (burial?) mound at Bakarlaka.

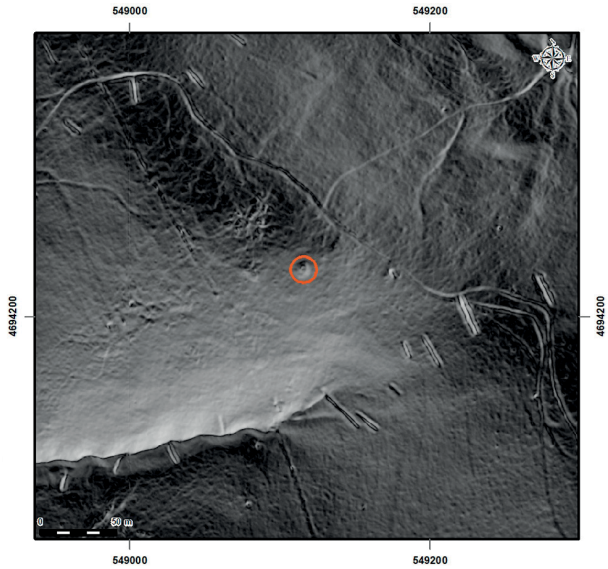

Fig. 86. (Burial?) mound at Bakarlaka on the LiDAR record.



Fig. 87. Burial mound at Bakarlaka, view from the south.



Fig. 88. Stone with slag on its surface: remains of metallurgical activity, from the area of the burial mound.

29. Burial Mound (?) Bakarlaka
35T 549117 4694235

(a) The site is located 2840m north-east from the centre of Rosen village, Sozopol municipality, 214m above sea level, in the middle part of the western slope of Bakarlaka peak. It is visible from the west (*fig. 85–86*).
(b) The site is a heap of small and mid-sized rough stone blocks, mound-like in shape, ca. 15m in diameter and ca. 1,3m high (*fig. 87*). Old treasure hunter's ditches appear in the upper part of the structure. A couple of burnt reddish stones with slag on them were observed in the mound (*fig. 88*). Other archaeological artefacts were not found. It is possible that the site is a burial structure (a tumulus) despite the fact that the soil contains metallurgical remains that may have fallen from the nearby metallurgical structures.
(e) Unclear, probably Late Iron Age.
(f) Survey 2015.

30. Prehistoric and Antique Site of Sozopol, Stadium (Gerena, Pozharnata)
35T 557326 4696079

(a) The site is located in an urban environment within the boundaries of the New Town of Sozopol, 580m south-east of the municipality building.

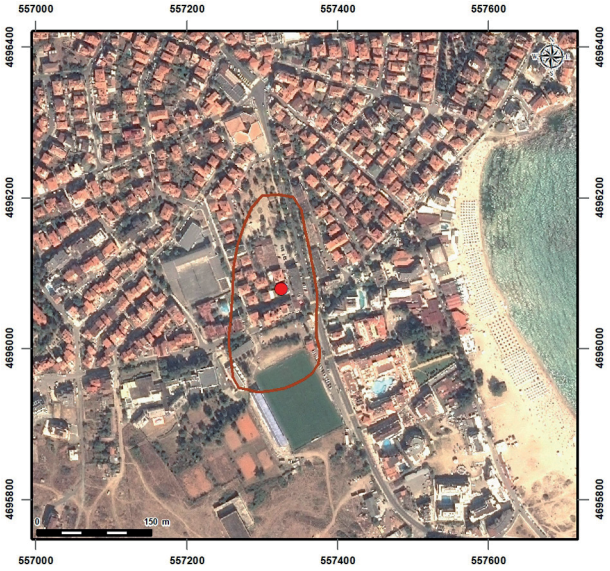

Fig. 89. Location and possible borders of the prehistoric and antique site Sozopol-Stadium.



Fig. 90. Late Neolithic oven at the site Sozopol-Stadium, found in 2014.

It is located 6m to 10m above sea level, on a sloping seashore facing east and south-east, about 270m from the contemporary shoreline (*fig. 89*). Probably in the past, a small stream was running about 50m to 70m south of the site. The Neolithic site is completely covered by a sand layer over 2m thick. The settlement is located approximately 6km west of the first low hills of the Medni Rid heights. Some publications list the site also as Sozopol-Gerena and Sozopol-Pozharnata.

(b) The earliest occupation is from the Late Neolithic. In different studied areas, 2,5ha in total, stone and clay structures and ovens (*fig. 90*) were discovered as well as pottery (*fig. 91*), stone and bone tools, and a few pieces of copper ore (malachite and azurite) (*fig. 92*). During rescue



Fig. 91. Pottery fragments from the Late Neolithic layer of the Sozopol-Stadium site.



Fig. 92. Late Neolithic finds at the site Sozopol-Stadium, found in 2014 (without scale).



Fig. 93. Marble column base with dedication to Zeus, reused in a Late Antique building at Sozopol-Stadium (without scale).



Fig. 94. Building from Late Antiquity uncovered at the excavations in 2014 at Sozopol-Stadium.



Fig. 95. View of the excavations at Sozopol-Stadium in 2014.

excavations at the site structures from later periods were discovered too: pits from the Early and Late Iron Age, a section of a terracotta pipe from the 4th cent. BC, graves from the Roman period and the Middle Ages, and a row of buildings and pottery kilns from Late Antiquity (*fig. 93, 94*).
(c) Some of the pits dating from the 6th to 5th cent. BC contained pieces of metallurgical slag probably from smelting of the copper ores in the vicinity.
(e) Late Neolithic, Early Iron Age, Archaic and Classical Greek periods, early Byzantine period, late Middle Ages.
(f) Revealed during the construction of several municipal and private buildings and other structures and partially investigated in several stages through rescue excavations in 2005, 2013, and 2014 (*fig. 95*).
(g) Klasnakov 2010, 14; Панайотова et al. 2014a, 267–270; 2014b, 270–273; Лещаков et al. 2015b, 76–78; Шаранков 2015, 1 f., 62–78

31. Late Neolithic Settlement Budzhaka, Sozopol 35T 558560 4694652

(a) The site is located on the Budzhaka peninsula, 4800m south-east of the Sozopol municipality building. It is located on a high terrace above the sea, along a slope facing south/south-east, 16m to 40m above sea level (*fig. 97*). A rich water source can be found about 500m south-west of the settlement in the area Kavatsite. The Neolithic site is completely covered by a layer of sand 1m to 2,5m thick (*fig. 96*). The settlement is situated ca. 6km west of the first hills of Medni Rid.
(b) On an area of 3,5ha more than ten Neolithic houses (*fig. 98*) and numerous pits were revealed as well as other stone and clay structures, handmade pottery (*fig. 99*), and tools of stone, flint and bone. Jewellery of malachite and pieces of copper ore were also found (*fig. 100*). Furthermore, quarries for stone from the Classical Greek period, graves and trenches for ancient vineyards, and a



Fig. 96. Late Neolithic dug-in structure under the sandy layer, uncovered at Budzhaka in 2009.

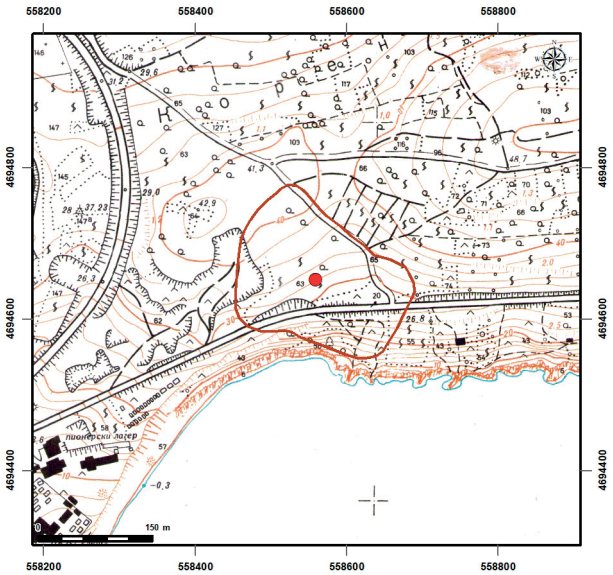

Fig. 97. Location of the Late Neolithic settlement at Budzhaka.



Fig. 98. Late Neolithic burned feature, uncovered at Budzhaka in 2007 (see fig. 97).

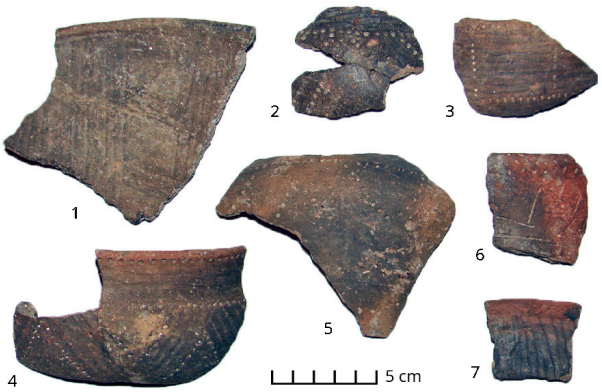

Fig. 99. Late Neolithic pottery from Budzhaka.

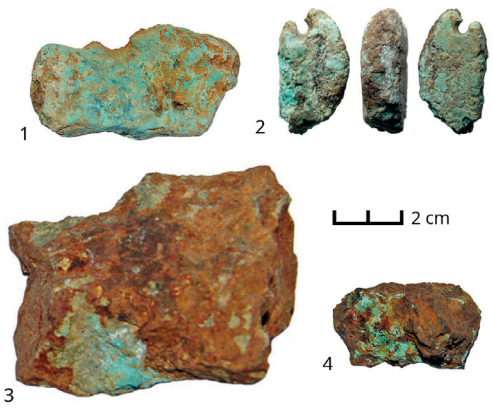

Fig. 100. Pendant and pieces of malachite uncovered at the excavations at the Budzhaka settlement.

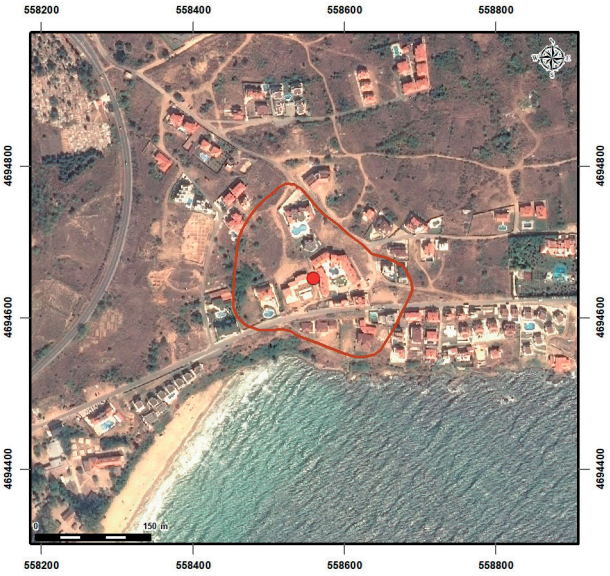

Fig. 101. Aerial view over the Budzhaka site.

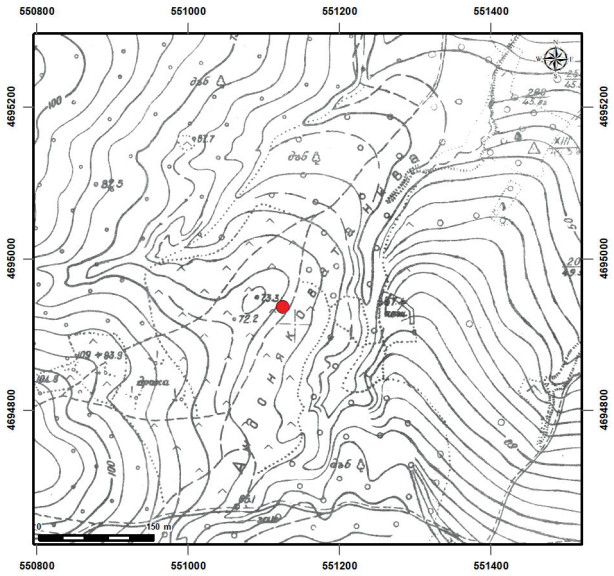

Fig. 102. Location of the settlement in Andonyakovata Niva.

church with graveyard from the Middle Ages (10th to 12th cent.) have also been studied within the boundaries of the prehistoric site.

(e) Late Neolithic, Classical Greek period, Middle Ages.

(f) Discovered during the construction of private holiday houses (*fig. 101*) and explored by various researchers through rescue excavations from 2006 to 2014.

(g) Панайотова et al. 2006, 244; Даскалов/Трендафилова 2007, 648–651; 2009, 91–108; Лещаков/Класнаков 2008, 54–57; Лещаков/Недев 2008, 49–51; Лещаков et al. 2008, 51–54; Лещаков 2009, 71–74; Лещаков/Самичкова 2010, 56–58; Klasnakov 2010, 14; Класнаков et al. 2011, 65–68; Недев et al. 2008, 309–313; Петкова/Лещаков 2015, 73–76; Лещаков et al. 2017b, 757–760; Стойчев et al. 2014, 54–57; Leshtakov 2011, 135.

32. Settlement Andoniyakovata Niva 35T 551126 4694936

(a) The site is located 4500m north-west from the centre of Ravadinovo village, Sozopol municipality. It extends to the low foothills of Medni Rid, along a slope facing south-east, 70m to 73m above sea level (*fig. 102*). The main part of the site is covered by a dense forest, part of it reaches into a small area of arable land.

(b) On an area of ca. 0.2ha scattered pottery fragments of wheel-made pottery and some mid-sized and large rough stone blocks were observed suggesting the former presence of a building.

(e) Unclear, possibly Greek and Roman periods.

(f) Survey 2013.

33. Mine and Metallurgical Site Surneshko Kladenche 35T 550198 4693355

(a) The site is located 4800m north-west from the centre of Ravadinovo village, Sozopol municipality 250m to 280m above sea level, at the southern foot of Bakarlaka peak and along the eastern slope of Medni Rid (*fig. 103*). A contemporary asphalt road leading to Bakarlaka peak runs through the western sector of the site.

(b) Few pottery fragments from vessels made on the potter's wheel appear in the surrounding area.

(c) Two parallel fissures oriented north-east/north-west were registered (*fig. 104*). The northern one is visible for a length of 120m and up to 10m wide. The southern one is ca. 90m long and up to 14m wide. Both fissures are badly damaged, eroded and their depth is about 1m. The region is heavily altered by modern constructions and ore mining activities that have ruined the area around the ancient fissures.

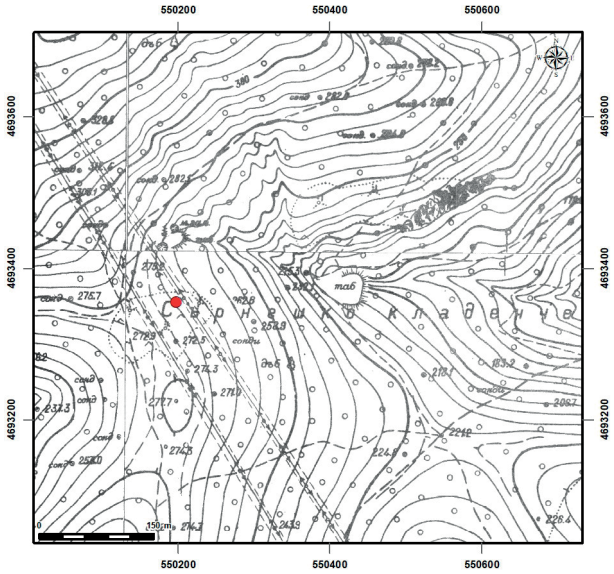

Fig. 103. Location of the ancient mine and metallurgical site Sarneshko Kladenche.

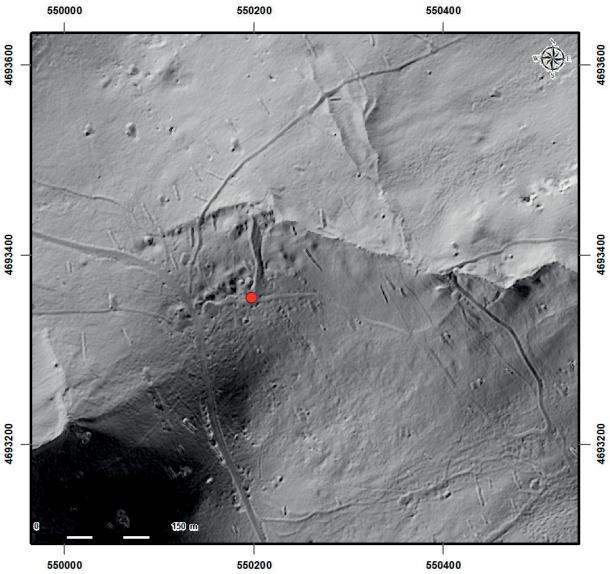

Fig. 104. Traces of ancient mining in the area of Sarneshkoto Kladenche on the LiDAR record.

Two spots of red fired clay and burnt stones ca. 1m by 1m in size were observed on the terrain south of the southern workings (*fig. 105*). Probably these structures are remains of furnaces for metallurgical treatment of ore.

(e) Greek and Roman periods.

(f) Surveys 2010, 2014.

(g) Черных 1978, 22; Панайотова et al. 2010, 586.



Fig. 105. Remains of a collapsed metallurgical kiln in the area of Sarneshkoto Kladenche

34. Fortress Oshilenoto Bairche 35T 550103 4693010

(a) The site is located 3500m east from the centre of Rosen village, Sozopol municipality, 296m above sea level, on the top of the Oshilenoto Bairche hill 1090m south of Bakarlaka peak (*fig. 106*). There is a wide panorama to the west and south-west to the Rosenska river valley (Ropotamo).

(b) The fortress is rectangular in plan, oriented north-east/south-west and 26m by 20m in size (*fig. 107*). On the terrain walls of a mean thickness of 1.6m can be traced. They are built as a dry masonry with rough stone blocks (*fig. 108*). The preserved height reaches up to 1m. The wall has a well-shaped face and consists of local rocks (*fig. 109*). The interior of the fortification is partially covered with shrubs on bumpy bedrock; therefore, the cultural layer is most likely very thin. A

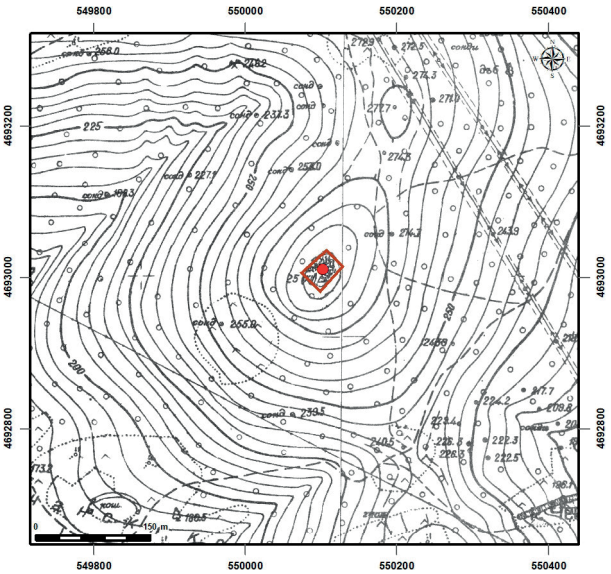

Fig. 106. Location of the Oshilenoto Bairche fortress.

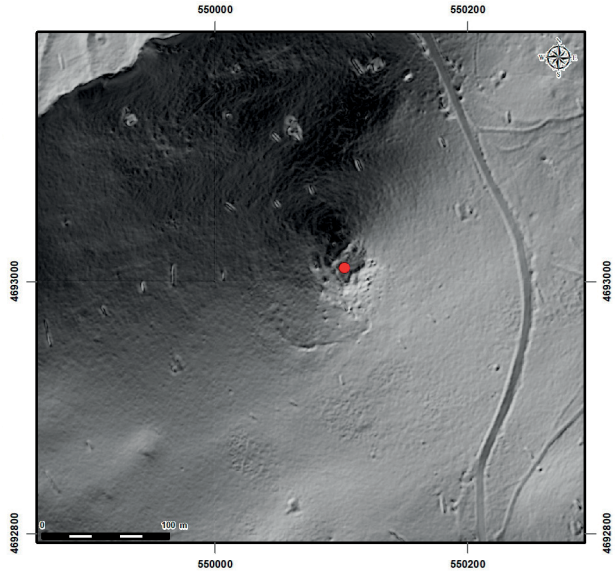

Fig. 107. Surface shape of the Oshilenoto Bairche fortress on the LiDAR record.



Fig. 108. Section of the course of the fortification wall.

few fragments of badly damaged amphora sherds were found during the survey.

(e) Greek and Roman periods.

(f) Surveys 2010, 2014, 2015.

(g) Лещаков/Класнаков 2011, 584.



Fig. 109. Outside of the south-western fortification wall.

35. Metallurgical Site Karakachanski Kolibi 35T 549742 4692618

(a) The site is located 3120m east from the centre of Rosen village, Sozopol municipality. It is located 160m to 180m above sea level, along with the middle sector of the west slope of Medni Rid (*fig. 110*). The fortress of Oshilenoto Bairche is situated 530m south-west of it, and 650m west of the ancient mine of Propadnala Voda. The terrain of the site is a pasture-ground, overgrown with bushes, with cattle fences installed during recent times.

(b) Numerous pieces of metallurgical slag and sherds from wheel-made pottery were found over an area of 2.5ha (*fig. 111*). The slag can be detected easily in the more exposed sections of the dirt road, but areas of higher concentration also are visible in the surrounding areas covered with vegetation.

(c) The slag is dark, dense, porous inside and occasionally with traces of oxidised copper minerals. Fired stones and pieces of fired clay with slag sticking on them were also found on the terrain. The geophysical survey in 2015 confirmed the uneven distribution of metallurgical remains. Probably the site represents remains of a complex of primary smelting installations running with minerals from the nearby mines (*fig. 112*).

(e) Greek and Roman periods.

(f) Surveys 2014, 2015.

(g) Черных 1978, 22; Георгиев 1987, 34–36; Лещаков/Класнаков 2011, 584; Лещаков et al. 2016b, 941–944.

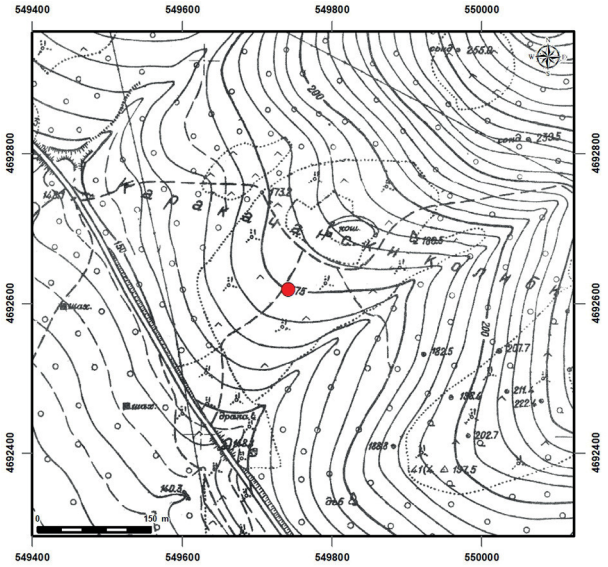

Fig. 110. Location of the metallurgical site Karakachanski Kolibi.

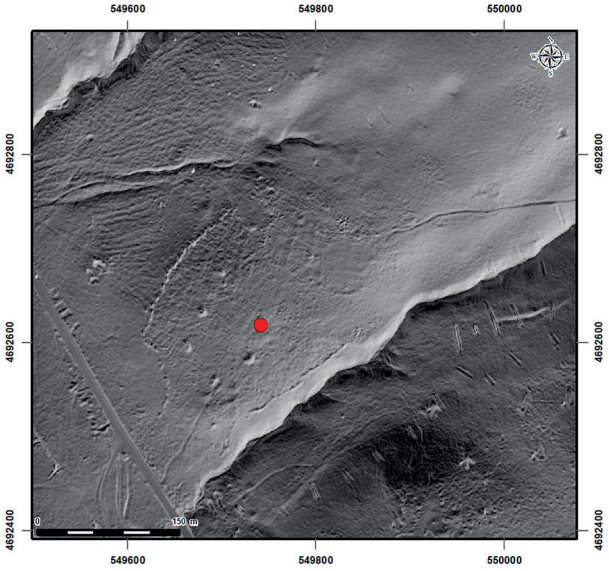

Fig. 112. Surface shape at the Karakachanski Kolibi site and part of the western half of the ancient mine Propadnala Voda on the LiDAR record.



Fig. 111. Pithos fragments and slags from the metallurgical site Karakachanski Kolibi.



Fig. 113. Ancient mine Propadnala Voda, view from east.

36. Mine and Metallurgical Site Propadnala Voda 35T 550460 4692717

(a) The site is located 4500m west of the centre of Ravadinovo village, Sozopol municipality. It can be followed along the lowest sector in the gully of Propadnala Voda to continue along the east slope of the ridge of Medni Rid (*fig. 113*) then crossing it to continue along its west side. The site is in a deforested and rocky area. The highest point of the mine is 250m above sea level; on the east slope 170m; and on the west slope up to 230m above sea level.



Fig. 114. Stone tool for crushing ore uncovered in the area of the Propadnala Voda mine.

(b) Archaeological surveys on the site conducted during many years resulted in a rich collection of stone tools and a large amount of fragments of wheel-made pottery. A couple of fragments of querns were also found (one of them of Olynthus type) probably used to crush ore. Stone tools made of flat natural stone from a solid rock (*fig. 114*), were used as hammer stones for the



Fig. 115. Pottery fragments from the Late Archaic period uncovered on the heap of the Propadnala Voda mine.

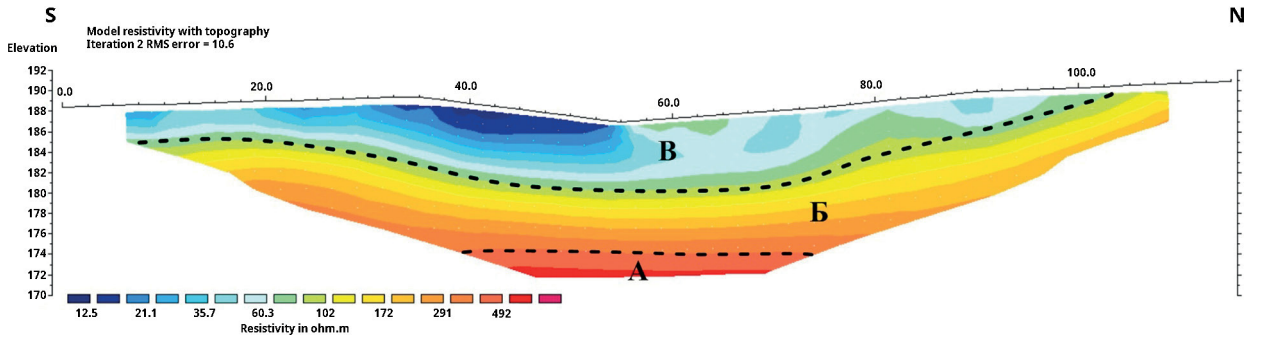

Fig. 116. Electrical resistivity tomography cross-section from the ancient mine in the Propadnala voda area (after Лещаков et al. 2016b, обр. 3)

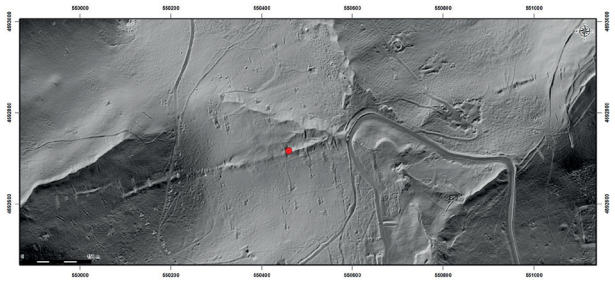

Fig. 117. Traces of ancient mining in the area of Propadnala Voda on the LiDAR record.

crushing of ore too. The pottery from the area of the mine dates to the second half of the 6th to early 5th cent. BC (Late Archaic period). Fragments of imported amphorae predominate, and few fragments of imported fine ware with brown varnish occur. Black-glazed sherds also appear (*fig. 115*). In the area of the second work described below few fragments of wheel-made pottery and pieces of slag were collected.

(c) The ancient mine is linear in plan, oriented north-east/south-west ranging over a length of ca. 470m, at a maximum width of ca. 17m to 20m (*fig. 116–117).* The visible depth reaches 3m. A heap of small rough stone blocks is located on the northern edge of the working area. It contains numerous pieces of copper ore. The mine follows the ore vein whose richest part close to the surface was exploited. Three compact areas oval in shape and measuring up to 2m^2, consisting of burnt clay pieces were registered in the lower sector of the mine, over the heap and along the gully edge. The areas also contain stones bearing clear traces of heating (*fig. 118–120*). The structures are remains of smelting furnaces.

A second linear fissure could be identified 350m north-east of the east end of the main mining area described above and along the south-east slope of the hill on slightly sloping terrain, 195m to 205m above sea level. This mine follows the main vein of



Fig. 118. Remains of metallurgical kilns on the heap of the Propadnala Voda mine.



Fig. 119. Remains of a metallurgical kiln north of the Propadnala Voda mine.

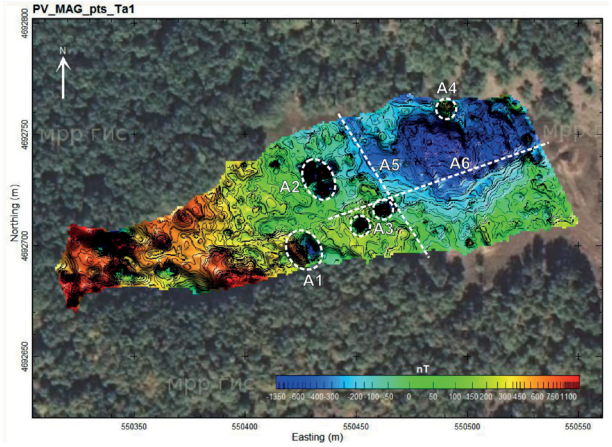

Fig. 120. Map of the anomalous geomagnetic field Ta1 of the ancient mine in the Propadnala Voda area, data from 2016 geomagnetic survey (after Лещаков et al. 2016b, обр. 1)



Fig. 121. Chiplaka fortress, view from the west.

Propadnala Voda and can be traced for a length of 94m, at a width of 6m to 8m and a depth of up to 1.5m. Its waste dump is on the south-eastern side of the trench and contains scattered pieces of copper minerals. Traces of ancient mining and remnants of metallurgical structures were recognised in the area of the site.

(d) Partly oxidised deposit with a predominance of secondary copper minerals, relics of copper sulphides, the bedrock presumably is a magmatic diabase, or a volcanoclastic rock.

(e) Prehistoric activity uncertain, 6th to 5th cent. BC (Late Archaic period), Classical Greek period.

(f) Surveys 2010, 2013 to 2016.

(g) Георгиев 1987, 36; Лещаков et al. 2015a, 850 f.; 2016b, 941–944; Лещаков et al. 2017a, 715 f.

37. Chiplaka Fortress
35T 551148 4692560

(a) The site is located 3770m west from the centre of Ravadinovo village, Sozopol municipality. The fortress is 210m to 218m above sea level, rising on the flat ridge of a hill (*fig. 121*) 550m south-east of the ancient mine of Propadnala Voda and 260m north-west of the new Sozopol municipal dunghill site.

(b) The fortress has a rectangular plan with sides of 94m north/south by 87m east/west (*fig. 122*). It is orientated according to the compass points with a very slight deviation to north-west/south-east, probably due to the configuration of the terrain. The visible parts of the walls, 5m to 6m wide and 0.5m to 1m high, look like a pile of mid-sized

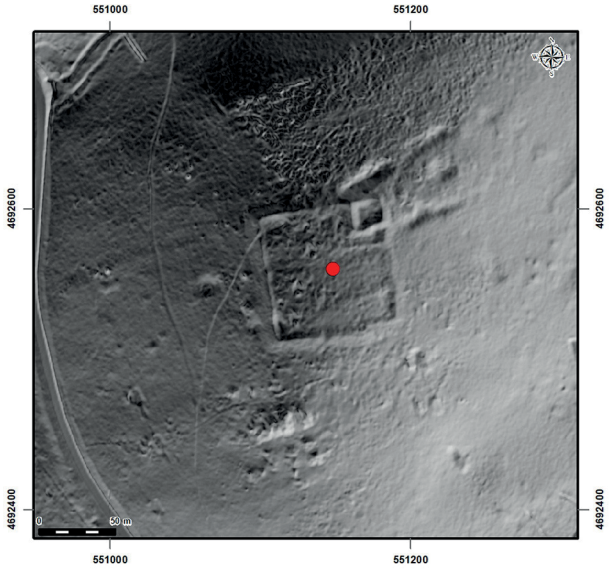

Fig. 122. Surface shape of the Chiplaka fortress on the LiDAR record.



Fig. 123. Stone remains of the southern wall of the Chiplaka fortress.



Fig. 124. Stone remains of the western wall of the inner fortification, view from inside.

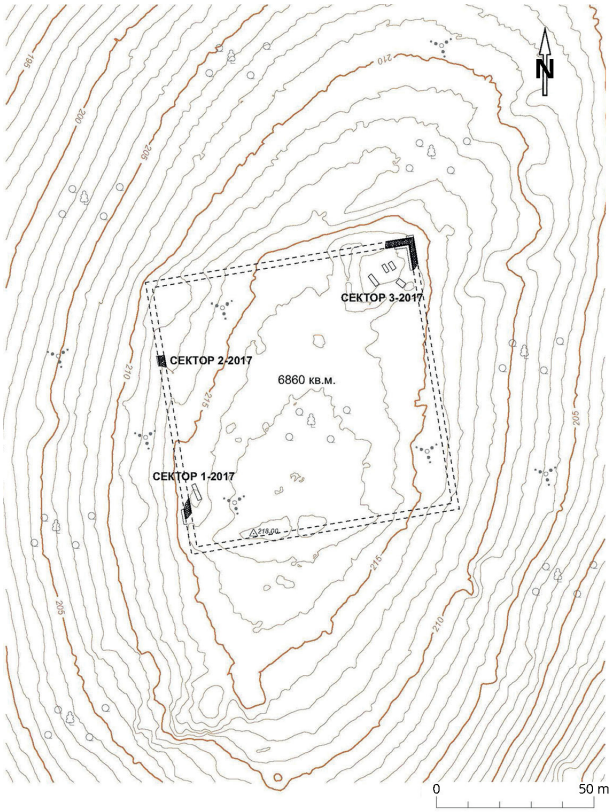

Fig. 125. Map of Chiplaka fortress with investigated sections in 2017 (after Девлова/Киров 2018, обр. 1).

and large rough stone blocks 5m to 6m wide and 0.5m to 1m high (*fig. 123*). A small inner rectangular fortification measuring 23m north/south and 29m east/west is located in the north-east corner of the fortress. This structure has been inserted into the main fortification employing its north and east walls. The west and south walls of the inner fortification are preserved up to 1.5m in height and 7m to 8m in width (*fig. 124*). The interior contained some fragments of secondarily fired daub and a small amount of wheel-made pottery. In 2017 an archaeological excavation was carried out at the site. A sector of the inner fortification face was revealed as well as some segments of the outer fortification wall (*fig. 125*). The walls were constructed of trimmed stone blocks bound with mud and arranged in regular manner forming regularly looking wall faces. The interior between the wall faces is filled with smaller stones also carefully arranged in rows (*fig. 126*). The width of the walls varies between 1.6m and 2.2m. The research in 2017 brought to light numerous archaeological artefacts including fine black-glazed ware, cups, fish dishes and bowls (*fig. 127*) and amphorae from Thasos, Chios and Mende (*fig. 128*). Fragments of architectural ceramics – *imbrices* and *tegulae* – also were found. The artefacts date from the mid-5th cent. BC to the second half of the 4th cent. BC. Among these rich Late Classical Greek



Fig. 126. Inner surface of the eastern fortification wall of the Chiplaka fortress uncovered in 2017.

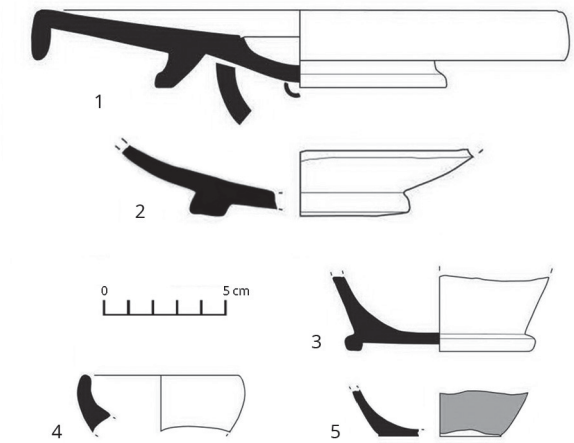

Fig. 127. Black glazed ware from the excavations at Chiplaka fortress in 2017 (after Девлова/Киров 2018, обр. 3).

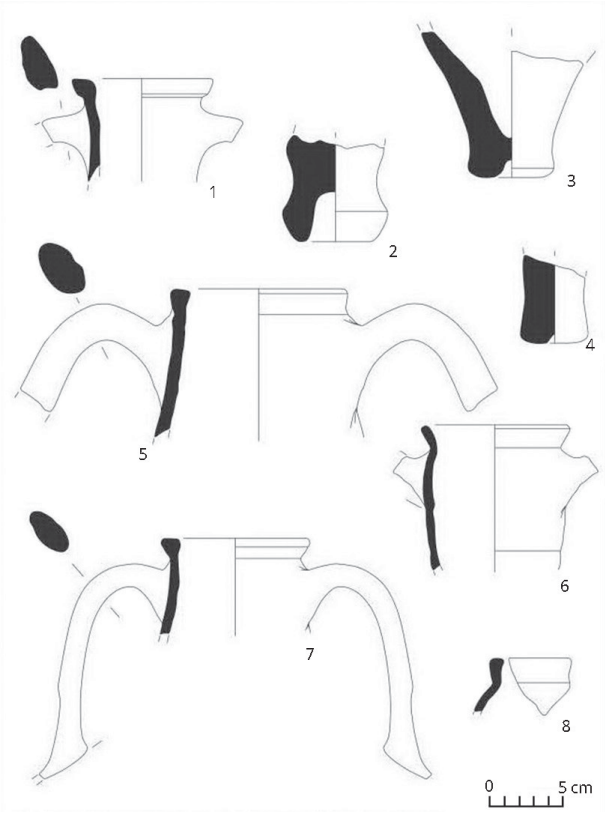

Fig. 128. Cargo amphorae from the excavations at Chiplaka fortress in 2017 (after Девлова/Киров 2018, обр. 3).

artefacts a stone axe that can be typologically dated to the Late Neolithic or the Chalcolithic was discovered. This prehistoric find, so far unique, unambiguously indicates the human presence in the area during prehistory. The construction of a Classical Greek fortress in the zone between the mines of Chiplaka and Propadnala Voda exploited in the same period that the mines were exploited is hardly a coincidence, and all three sites should be considered as a complex of a protecting fortress and two particular mining and ore processing centres.

(e) Late Classical Greek period.

(f) Surveys 2015, 2016, excavations 2017.

(g) Лещаков et al. 2016a, 880 f.; 2017a, 715 f.; Девлова/Киров 2018, 171–173.

38. Settlement (?) Bivolskata Saya 35T 551686 4693186

(a) The site is located 3310m north-west from the centre of Ravadinovo village, Sozopol municipality. It covers a naturally protected cape-like area (*fig. 129*) elongated in east/west direction in the central parts of the eastern slope of Medni Rid,

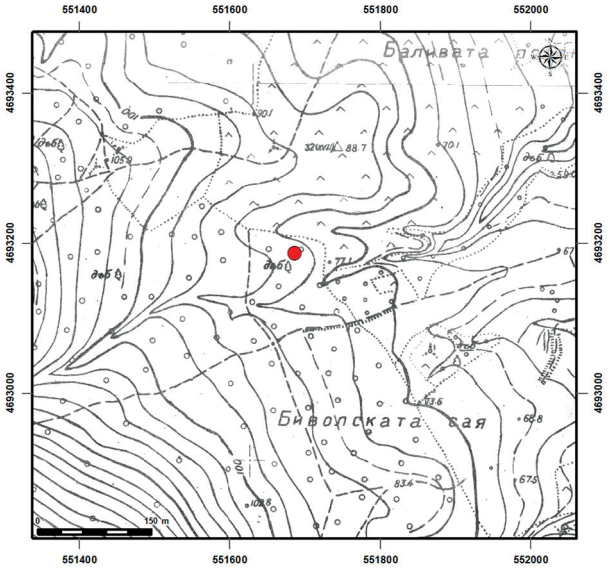

Fig. 129. Location of a settlement (?) at the Bivolskata Saya site.

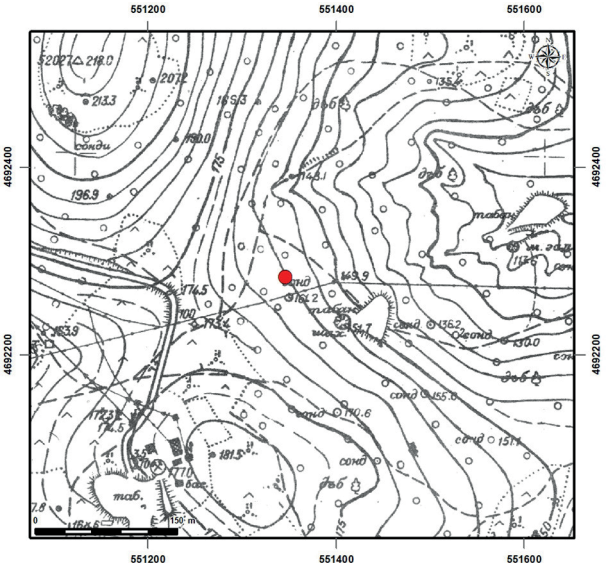

Fig. 131. Location of small mounds in the Chiplaka site.

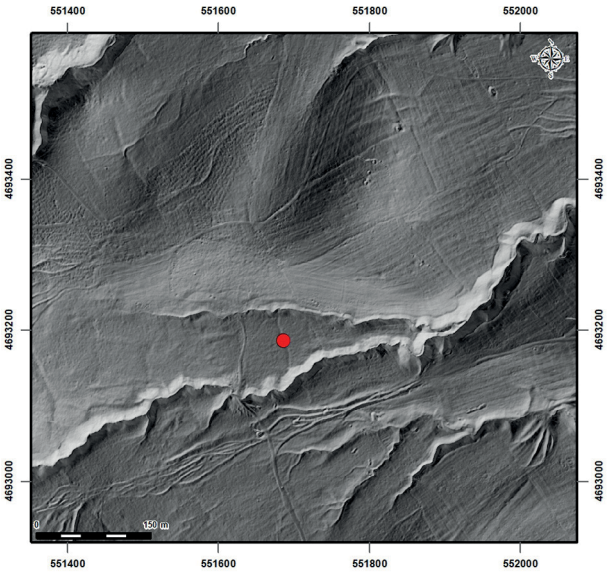

Fig. 130. Surface structure of the Bivolskata Saya site on the LiDAR record.

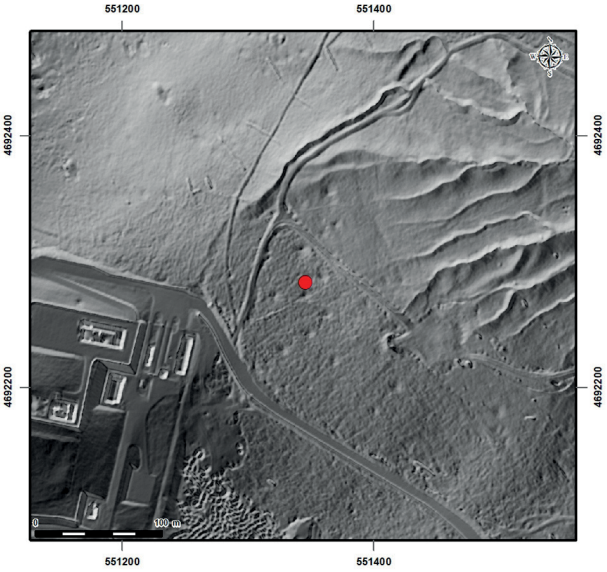

Fig. 132. Mound-like structures at the Chiplaka site on the LiDAR record.

65m to 85m above sea level. Deep gullies (15m to 25m) surround it from the north and the south with seasonal streams running in them (*fig. 130*). The natural access is from the west.

(b) The terrain is overgrown with trees, grass and shrub vegetation and during the survey the visibility was poor. From the west, the site is surrounded by an embankment-like structure of possible anthropogenic origin. Some fragments of pottery made on a potter's wheel were found on site.

(e) Unclear, Classical Greek or later periods.

(f) Survey 2015.

39. Small 'Burial Mounds' Chiplaka 35T 551346 4692283

(a) The site is located 3580m west from the centre of Ravadinovo village, Sozopol municipality, 150m to 160m above sea level, on the upper part of a slope (*fig. 131*) facing east, at the south-east foot of the hill with Chiplaka fortress on its top.

(b) A complex of ten to twelve mound-like structures, scattered without any visible order over an area of about 0.8ha (*fig. 132*). The mound-like structures consist entirely of small to mid-sized

rough stone blocks. Their diameters are between 3m to 4m and 6m to 8m, less than 1m in height. No archaeological artefacts were found on site. Topographically the structures seem to be related to the Chiplaka fortress.
(e) Unclear.
(f) Survey 2016.
(g) Лещаков et al. 2017a, 716.

40. Burial Mound Kokardzhata 1 35T 549573 4692218

(a) The site is located 3300m south-east from the centre of Rosen village, Sozopol municipality, on the upper part of a slope facing south-west (*fig. 133*), in a fairly flat forest terrain 137m above sea level, 870m south-west of the Karakachanski Kolibi metallurgical centre.
(b) The tumulus is of broad hemispherical shape, ca. 20m in diameter and 2m in height (*fig. 134*). The mound is made of soil without traces of contemporary violations. Archaeological artefacts were not found on site.
(e) Unclear, Classical Greek or Roman Periods.
(f) Survey 2010, 2014.
(g) Лещаков/Класнаков 2011, 584.

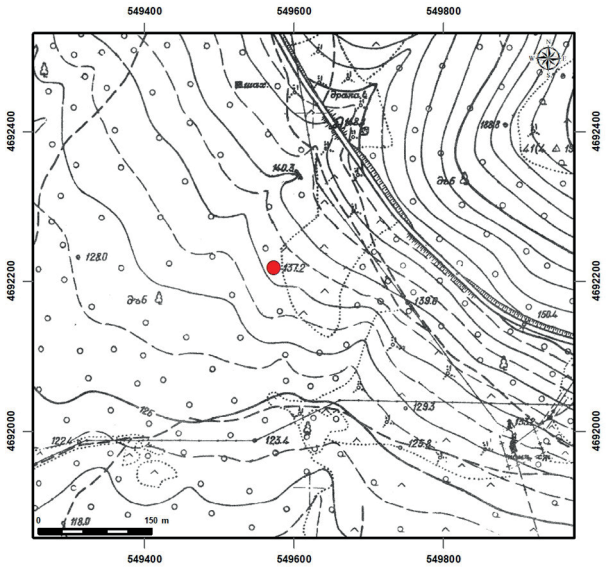

Fig. 133. Location of the burial mound Kokardzhata 1.



Fig. 134. Burial mound Kokardzhata 1, view from the south-west.

41. Burial Site Kokardzhata 2 35T 550142 4691852

(a) The complex is situated 3660m south-east from the centre of Rosen village, Sozopol municipality. It is located 128m to 130m above sea level, on the middle part of a slope facing south/south-west (*fig. 135*). The burial site is situated 670m south-east of the single tumulus Kokardzhata 1.
(b) The burial site consists of three tumuli arranged along an almost straight line of 145m length and oriented north-west/south-east (*fig. 136*). The north-westernmost tumulus in the group is less visible on the terrain, its diameter is 12m and the height is approximately 1m (*fig. 137*). The mound is made of soil. Archaeological artefacts were not found. The central tumulus displays similar features: 8m in diameter and 0.5m in height. The mound is made of soil, and there are no modern treasure hunter's pits. Archaeological



Fig. 135. Location of the Kokardzhata 2 burial site.

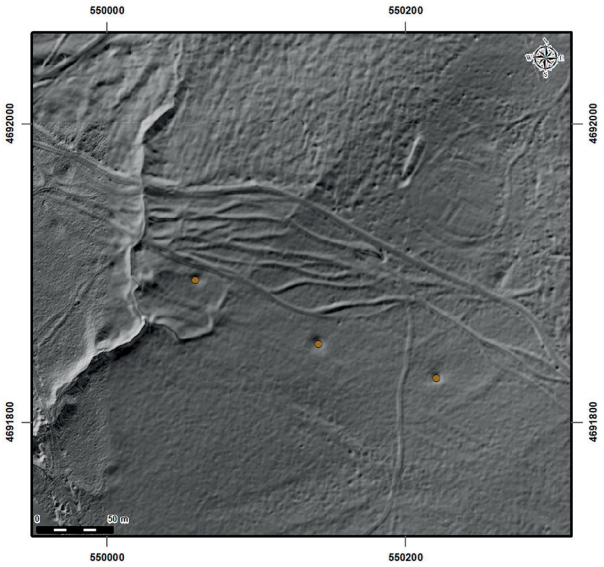

Fig. 136. Surface structure of the Kokardzhata 2 burial site on the LiDAR record.



Fig. 137. North-western burial mound from the Kokardzhata 2 burial site, view from the south.



Fig. 138. South-eastern burial mound from the Kokardzhata 2 burial site, view from the south.

artefacts were not found. The south-east tumulus is 12m in diameter and approximately 1m in height. The mound is made of small and mid-sized rough stone blocks, the soil is almost entirely missing (*fig. 138*). Damages were not observed, and archaeological artefacts were not found.

(e) Unclear, Classical Greek or Roman periods.

(f) Survey 2015.

42. Aivadzhik Settlement and Metallurgical Site 35T 544914 4693378

(a) The site is located 1800m north-west from the centre of Rosen village, Sozopol municipality. It lies at the south-east foot of the Alla Tepe peak (*fig. 139*), 100m to 125m above sea level, over a terrace slightly sloping to the north-east, along the right bank of a deep ravine with a seasonal stream of a right-hand tributary of the Otmanli river, the spring of which is very close (*fig. 140*).

(b) On the terrain, which is a cultivated field, four large areas of rough stone blocks, architectural and household pottery was observed (*fig. 141*). The areas mark partially destroyed houses of stone construction. Within the borders of the areas, as well as between them, there were numerous pieces of thick black slag with no visible traces of copper minerals (*fig. 142*). The pottery of the site is dating to the early Byzantine period (*fig. 143*). In the south-west periphery of the site, two prehistoric stone tools were found: an adze and a hammer displaying the peculiar concavities in the centre of both flat sides (*fig. 144*). There was no prehistoric pottery or other artefacts that could be related with these tools.

(e) Neolithic–Chalcolithic?, early Byzantine period.

(f) Survey 2014.

(g) Делев 1990, 143; Делирадев 1953, 87; Лещаков et al. 2015a, 850 f.; Шкорпил/Шкорпил 1891, 121.

43. Burial Site Aivadzhik 1 35T 544460 4692994

(a) The site is located 2030m north-west from the centre of Rosen village, Sozopol municipality, at



Fig. 139. Settlement and metallurgical centre Aivadzhik, view from the south-east.



Fig. 142. Fragment of a metallurgical kiln from the Aivadzhik site.

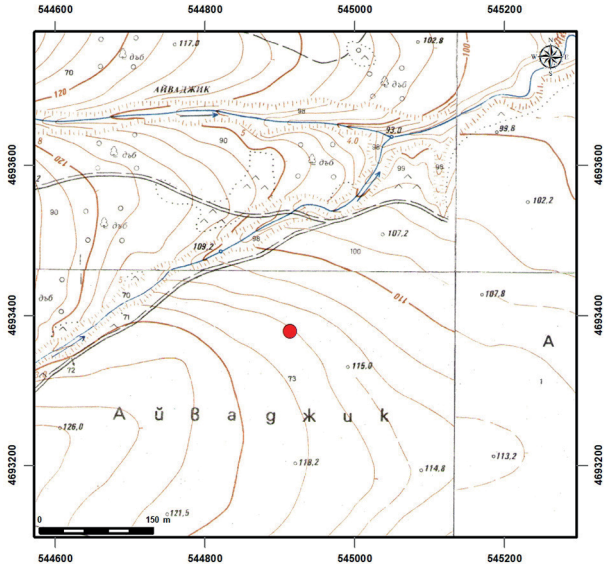

Fig. 140. Location of the settlement and metallurgical centre Aivadzhik.



Fig. 143. Late Antiquity pottery from the Aivadzhik site.

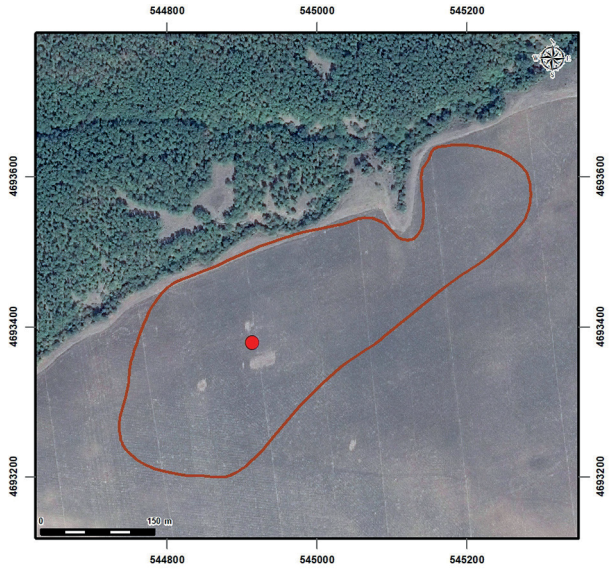

Fig. 141. Satellite image showing today's situation with borders of the Aivadzhik site according to the dispersal of the archaeological finds.



Fig. 144. Prehistoric stone tools and fragments of a tegula with an imprint of an animal foot found at the Aivadzhik site.

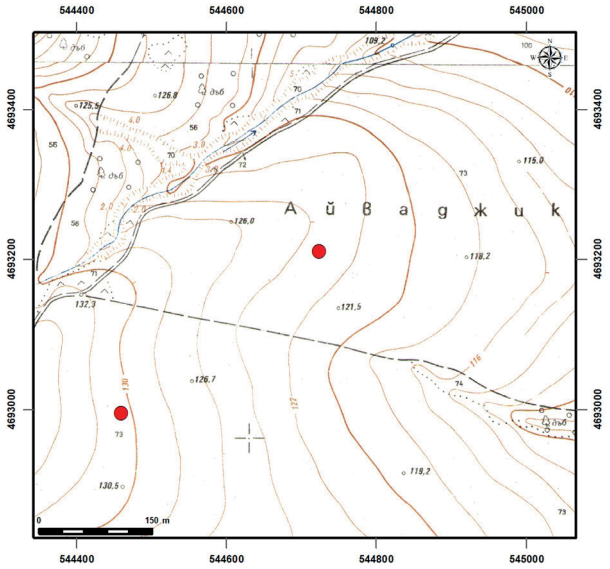

Fig. 145. Location of the Aivadzhik 1 burial site.



Fig. 146. South-western burial mound of the Aivadzhik 1 burial site, view from the north-east.



Fig. 147. Fragments of ceramic building materials from the destroyed grave in the south-western burial mound of the Aivadzhik 1 burial site.



Fig. 148. North-eastern burial mound of the Aivadzhik 1 burial site, view from the south-east.

the south-east foot of the Alla Tepe peak, 122m to 131m above sea level, on a terrace slightly sloping to the east, along the right bank of a deep ravine with the seasonal stream of a right-hand tributary of the Otmanli river.

(b) The burial site consists of two tumuli at a distance of 340m from each other (*fig. 145*).

The south-west tumulus is 15m in diameter and 0.5m to 0.6m in height (*fig. 146*). The mound is made of soil. The central sector of the tumulus is damaged by a treasure hunter's trench, and its mound contains brick fragments from a destroyed grave (*fig. 147*), probably from the Roman period.

The north-east tumulus, located next to the borders of the site 42, is 18m in diameter and 0.8m in height (*fig. 148*). The mound is made of soil. Scattered sherds of early Byzantine pottery were found on the surface probably coming from the settlement.

(e) Roman and early Byzantine periods.

(f) Surveys 2010, 2014.

(g) Лещаков/Класнаков 2011, 584.

44. Burial Site Aivadzhik 2 35T 544859 4693766

(a) The site is situated 1980m north-west from the centre of Rosen village, Sozopol municipality. It is located at the south-east foot of the Alla Tepe peak, 109m to 117m above sea level, on a terrace sloping to the east, along the left bank of the Otmanli river. From the north, the terrace is limited by a shallow gully. The area is forested (*fig. 149*).

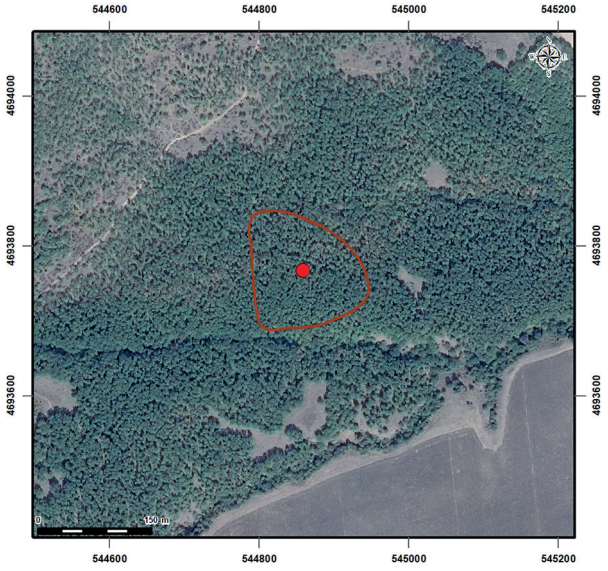

Fig. 149. Satellite image with the location and borders of the Aivadzhik 2 burial site.

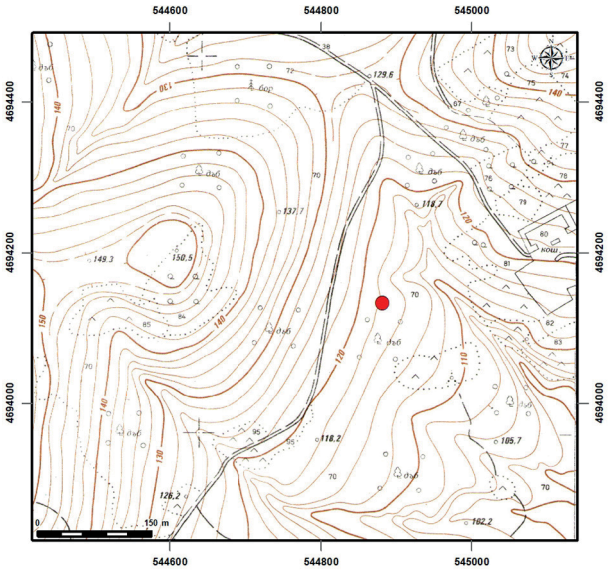

Fig. 151. Location of the Aivadzhik 3 burial site.

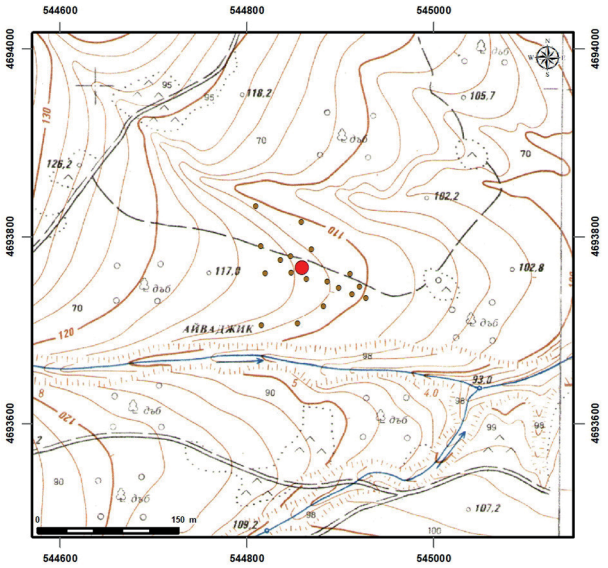

Fig. 150. Location of the Aivadzhik 2 burial site.

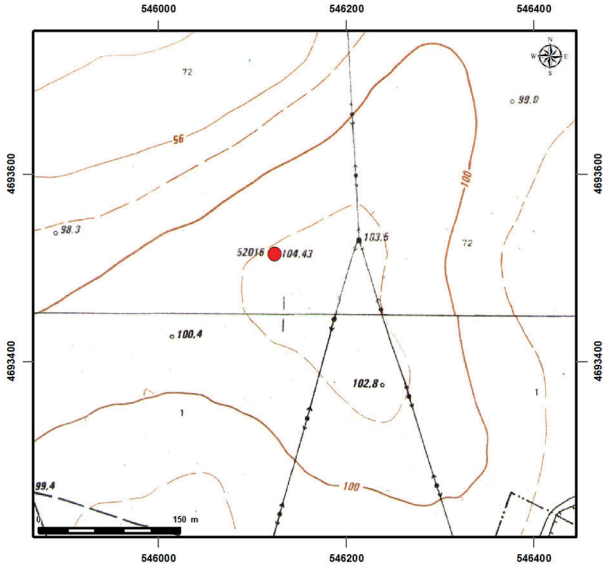

Fig. 152. Location of the burial mound Aivadzhik 4.

(b) The burial site consists of 18 low tumuli (*fig. 150*) of a diameter of less than 10m and up to 0.6m in height, scattered over an area of nearly 1.8ha. It is located at a distance of 190m from the northern periphery of site 42 and probably related to it. The tumuli are accumulated of soil, and most of them are damaged by treasure hunter's trenches. Archaeological artefacts were not found on the terrain.

(e) Roman period.

(f) Survey 2014.

(g) Лещаков et al. 2015a, 851.

45. Burial Site Aivadzhik 3 35T 544882 4694132

(a) The site is located 2300m north-west from the centre of Rosen village, Sozopol municipality at the eastern foot of the Alla Tepe peak, 117m to 128m above sea level, on a slope facing east (*fig. 151*). The area is forested.

(b) The burial site contains two tumuli at a distance of 230m from each other. The tumuli are of a similar size, ca. 20m in diameter and 1.2m to 1.5m in height. Their mounds are made of soil. There

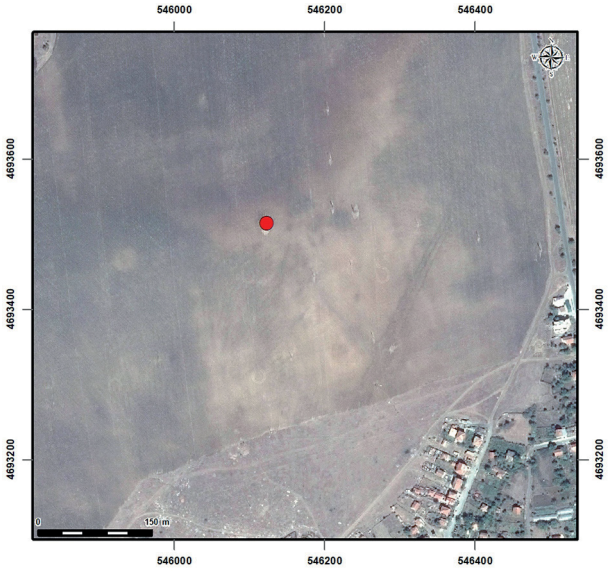

Fig. 153. Satellite image showing today's situation of the burial mound Aivadzhik 4 on the terrain.



Fig. 154. Burial mound Aivadzhik 4, view from the south-west.

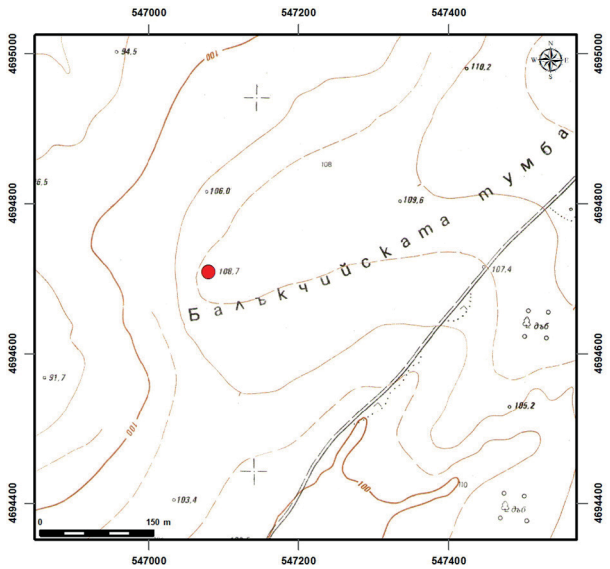

Fig. 155. Location of the burial mound Balakchiyskata Tumba.

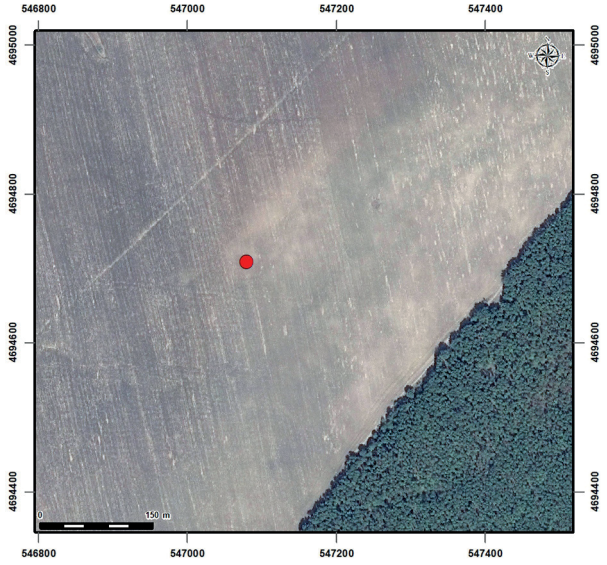

Fig. 156. Satellite image showing today's situation of the burial mound Balakchiyskata Tumba on the terrain.

are no treasure hunter's trenches, and archaeological artefacts were not found. The burial site is 760m north of site 42 and is probably related with this settlement.

(e) Unclear, possibly Roman period.

(f) Survey 2014.

46. Tumulus Aivadzhik 4
35T 546124 4693514

(a) The site is located 910m north-west from the centre of Rosen village, Sozopol municipality 102m to 104m above sea level on the flat sector of a low height along the right bank of the Otmanli river (*fig. 152*). The area is arable (*fig. 153*).

(b) The tumulus is 25m in diameter and 1.5m high (*fig. 154*). The mound consists of soil. The higher sector bears traces of an old treasure hunter's pit. Archaeological artefacts were not found. The tumulus is located 840m east of the north-east periphery of site 42 and possibly connected with it.

(e) Unclear, possibly Roman period.

(f) Survey 2014.

47. Tumulus Balakchiyskata Tumba
35T 547080 4694709

(a) The site is located 2020m north-west from the centre of Rosen village, Sozopol municipality



Fig. 157. Burial mound Balakchiyskata Tumba, view from the north-east.

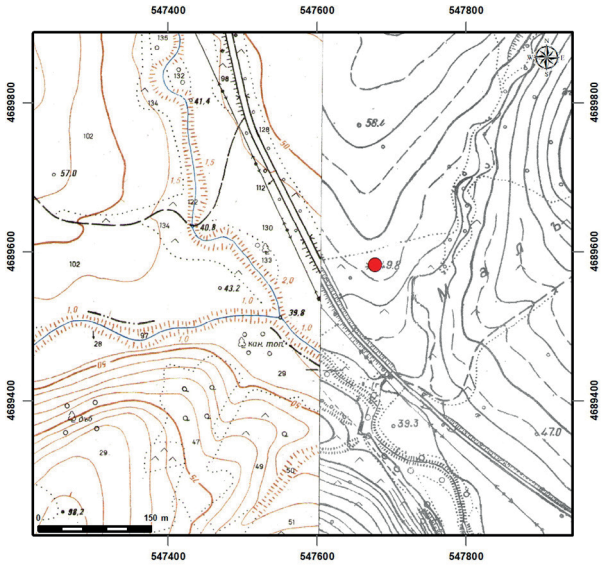

Fig. 158. Location of the burial mound Malak Murvat 1.

107m to 109m above sea level, at the foot of the western slope of Medni Rid (*fig. 155*), along the right bank of the Otmanli river. The area is arable (*fig. 156*).

(b) The tumulus is 30m in diameter and 1m high (*fig. 157*). The mound consists of soil. It is ploughed regularly and probably flat by this. Archaeological artefacts were not found. Satellite images show a dark spot 190m north-east of Balakchiyska Tumba, but it could not be localised when visiting on-site. Probably this is a trace of second tumulus of the same burial site which has been destroyed by agriculture of the field.

(e) Unclear, Classical or Roman periods.

(f) Survey 2014.



Fig. 159. Satellite image showing today's situation of the burial mound Malak Murvat 1 on the terrain.

48. Tumulus Malak Murvat 1
35T 547678 4689583

(a) The site is located 3340m south-east from the centre of Rosen village, Sozopol municipality 49m to 50m above sea level, at the foot of the western slope of Medni Rid, on a terrace facing south over the small stream catchment of the Ropotamo river (*fig. 158*). The terrain is overgrown with grass and shrubs (*fig. 159*).

(b) The tumulus is 12m in diameter and 1.2m high (*fig. 160*). There are no treasure hunter's ditches. A couple of large boulders appear on the top and along the slope. Archaeological artefacts were not found.

(e) Unclear, Classical Greek or Roman periods.

(f) Survey 2014.



Fig. 160. Burial mound Malak Murvat 1, view from the south-west.

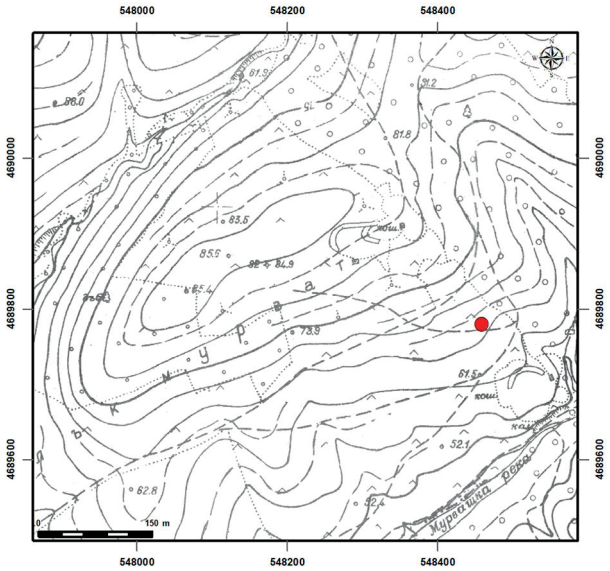

Fig. 161. Location of the burial mound Malak Murvat 2.

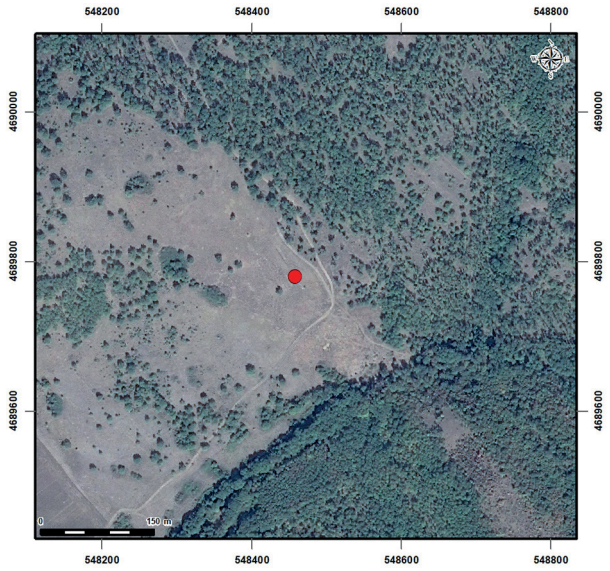

Fig. 162. Satellite image showing today's situation of the burial mound Malak Murvat 2 on the terrain.



Fig. 163. Burial mound Malak Murvat 2, view from the south-east.

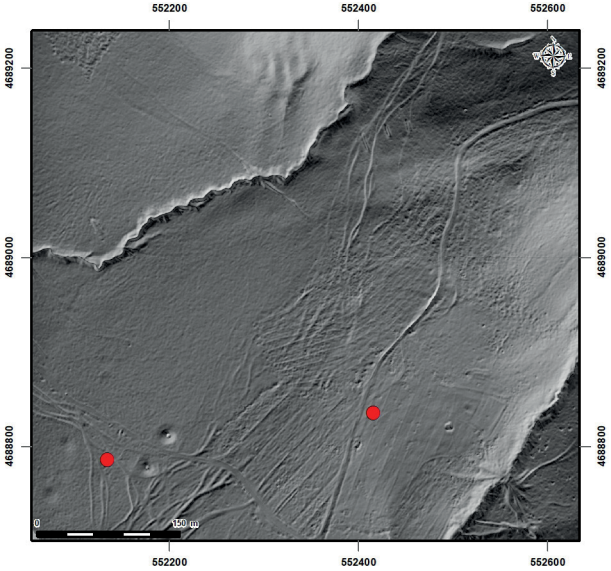

Fig. 164. Surface structure of the settlement (right) and tumulus necropolis (left) Veselie 1 on the LiDAR record.

49. Tumulus Malak Murvat 2
35T 548458 4689780

(a) The site is located 3520m south-east from the centre of Rosen village, Sozopol municipality 65m to 68m above sea level, on the lower sector of the south-east slope below the Malak Murvat height along the right bank of the Murvashka river (*fig. 161*). The terrain is densely overgrown with grass (*fig. 162*).
(b) The tumulus is 20m in diameter and 1.7m high (*fig. 163*). The mound is made of soil. Archaeological artefacts were not found. Fragments of wheel-made pottery appear 250m south-east of the tumulus in the bed of the Murvashka river as well as in a shallow trench along its right bank. Probably they are from a non-localised settlement.
(e) Unclear, Classical or Roman periods.
(f) Survey 2014.

50. Settlement (?) Veselie
35T 552416 4688836

(a) The site is located 2770m north-east from the centre of Veselie village, Primorsko municipality. It is situated 146m to 164m above sea level, lying on a slightly sloping terrace facing south (*fig. 164*). The site is located in the upper sector of the west slope of Medni Rid below the Lobodovo Kale peak,

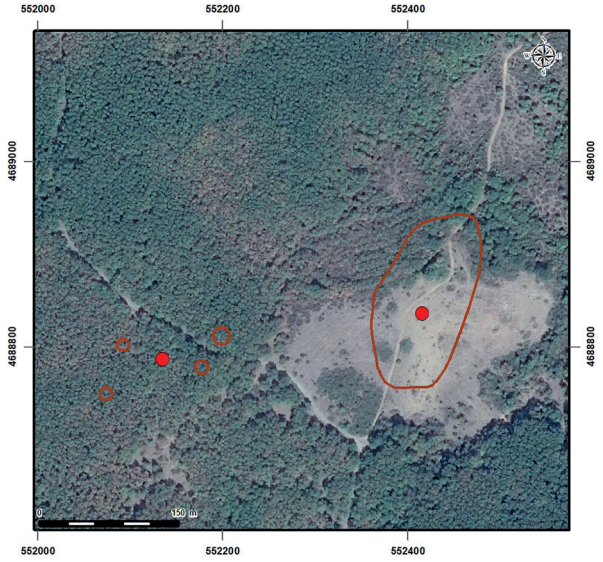

Fig. 165. Satellite image with location of the settlement (right) and tumulus necropolis (left) Veselie 1 showing today's situation on the terrain.

along the right bank of a small stream, a tributary of the Tiklite river. The terrain is a pasture overgrown with grass (*fig. 165*).

(b) A large number of pottery fragments appear on an area of 1.6ha: amphora sherds and wheel-made tableware and dating to the Classical Greek period. When visiting on-site, probably due to the nature of the terrain cover (*fig. 166*), no traces of buildings (stones or architectural ceramics) were observed. Most likely, the site is a suburban farm of the type known from the area of Apollonia Pontica. It can also be associated with the burial site located 280m to the south-west.

(e) Classical period, 5th to 4th cent. BC.

(f) Survey 2015.

(g) Лещаков et al. 2016a, 880 f.



Fig. 166. View to the Veselie site from the south.



Fig. 167. North-eastern burial mound, view from the south.



Fig. 168. South-eastern burial mound, view from the north.

51. Burial Site Veselie 1
35T 552135 4688786

(a) The site is situated 2610m north-east from the centre of Veselie village, Primorsko municipality. It is located 142m to 148m above sea level, on a slope facing south/south-west in the upper sector of the west slope of Medni Rid, below Lobodovo Kale. The terrain is overgrown with grass.

(b) The burial site consists of four tumuli close to each another (rising at a distance between 23m and 90m) covering an area of 0.9ha (*fig. 164*). It is situated 230m to the north-east of the periphery of Veselie settlement and most likely is related to it (*fig. 165*). The north-east mound (no.1 in the site) is 20m in diameter and 2.5m to 3m high (*fig. 167*). The tumulus is made of light brown clay soil. There is a treasure hunter's ditch with a visible depth of 1.5m in the central sector of the tumulus. Archaeological artefacts were not found, nor traces of a destroyed grave structure. The south-east tumulus (no. 2 in the site) is 18m in diameter and 1m high (*fig. 168*). The mound is made of light brown clay soil. There is a 0.5m deep treasure

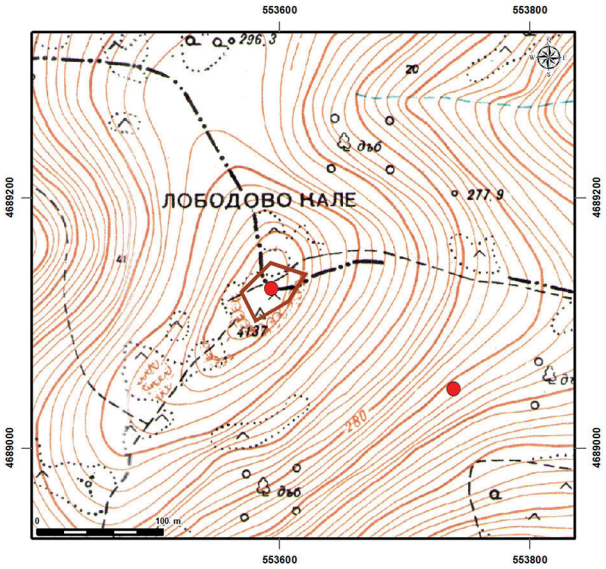

Fig. 169. Location of the Lobodovo kale fortress and burial mounds.

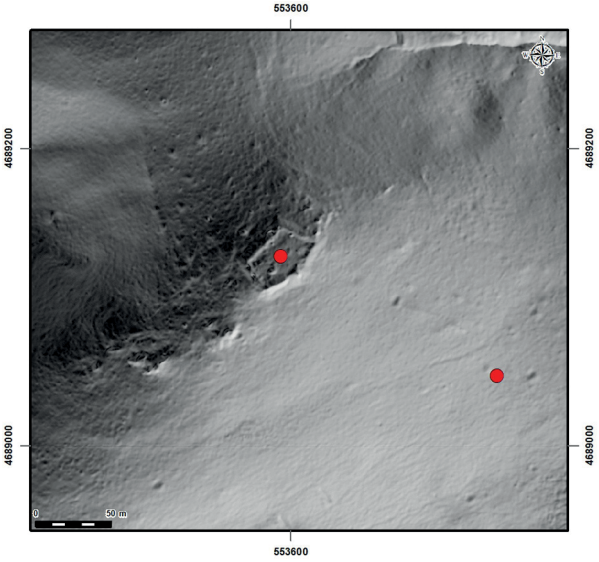

Fig. 170. Surface shape of the Lobodovo kale fortress and burial mounds on the LiDAR record.

hunter's ditch visible in the central sector of the tumulus. A couple of large rough stone blocks and a damaged fragment of a wheel-made vessel were found around the ditch. The south-west and north-west tumuli (nos. 3 and 4) are of a similar size, 12m in diameter and 0.5m high. They are less visible on the terrain and are not affected by treasure hunters. Archaeological artefacts were not found.

(e) 5th to 4th cent. BC?

(f) Survey 2015.

(g) Лещаков et al. 2016a, 881.

52. Lobodovo Kale, Fortress
35T 553593 4689127

(a) The site is located 3650m north-east from the centre of Veselie village on the intersection of three communities: most of it is situated in the Veselie domain and smaller parts in the Ravadinovo and Sozopol domains of the Primorsko and Sozopol municipalities. The fortress rises in the flatrocky sector of the Lobodovo kale peak, 314m above sea level (*fig. 169*). The slopes are steep on all sides and difficult to access. It has an excellent view to the seafront east of Medni Rid and west to the Rosenska and Ropotamo valleys.

(b) The fortress has an irregular pentagonal plan that follows the configuration of the terrain. It covers an area of 0.13ha. The walls are built of mid-sized rough stone blocks built in dry masonry (*fig. 171*). The preserved height of the walls is about 1m at an average width of 2m. In the interior of the fortification the local bedrock is visible, and the cultural layer is probably rather thin. No modern destructions are observed, and no archaeological artefacts were found. The fortress controls the north-east/south-west passage through one of the lower parts of Medni Rid and connects the Ropotamo river valley with the coast. It is one of the most important fortifications on the ridge of the mountain.

(e) Unclear, 1st mill. BC.

(f) Survey 2015.

(g) Делев 1990, 143; Венедиков/Фол 1976, 155 f.

53. Lobodovo Kale, Burial Mounds(?)
35T 553739 4689047

(a) The site is located 3690m north-east of the centre of Veselie village, Primorsko municipality in the upper sector of the south-east slope of Lobodovo Kale peak, 270m above sea level (*fig. 169*). The terrain is wooded.

(b) According a LiDAR recording there are dozens of positive terrain anomalies of similar dimensions on the north-east, east and south-east slope of Lobodovo Kale peak (*fig. 170*). Two of those lying on



Fig. 171. Stone riprap from the fortification wall of the Lobodovo kale.

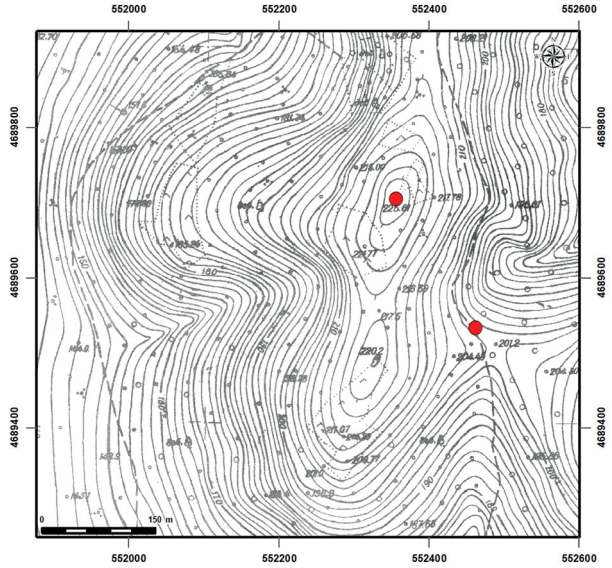

Fig. 172. Location of the necropolis Veselie 2.



Fig. 173. North-western burial mound from the necropolis Veselie 2, view from the south-east.



Fig. 174. South-eastern burial mound from the Veselie 2 burial site, view from the west.

the south-east slope were visited. They are small mound-like structures made of small and mid-size rough stone blocks. Their diameters are 4m to 5m and they are 0.5m to 0.8m high. Both structures were destroyed by treasure hunter's ditches, but archaeological artefacts were not found during the visit. Topographically the structures can be related with the fortress of Lobodovo Kale.

(e) Unclear.

(f) Survey 2015.

54. Burial Site of Veselie 2
35T 552356 4689705

(a) The site is located 3480m north-east from the centre of Veselie village, Primorsko municipality. It lies between the lands of Ravadinovo and Veselie villages. The burial site is 201m to 226m above sea level, on the ridge of a height and a saddle from the south-east (*fig. 172*). The terrain is wooded (*fig. 173*).

(b) The burial site consists of two tumuli located 210m apart (*fig. 174*). The north-west tumulus is 18m in diameter and 2.5m high. The mound is made of stone and earth. There is a treasure hunter's ditch in its central sector containing some mid-sized rough stone blocks. Archaeological artefacts were not found. The south-east tumulus is less pronounced on the terrain, 12m in diameter and ca. 1m in height. The mound is made of soil. There is a treasure hunter's ditch in its central sector with a visible depth of 1m. Archaeological artefacts were not found.

(e) Classical Greek or Roman Period.

(f) Survey 2015.

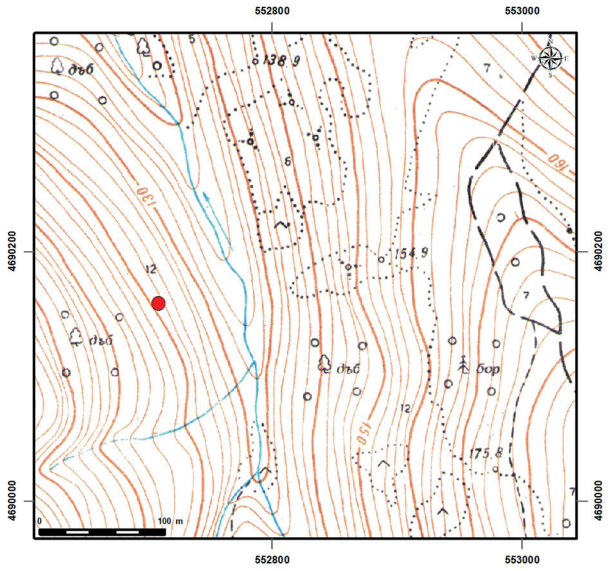

Fig. 175. Location of a group of small stone tumuli Ravadinovo 1.

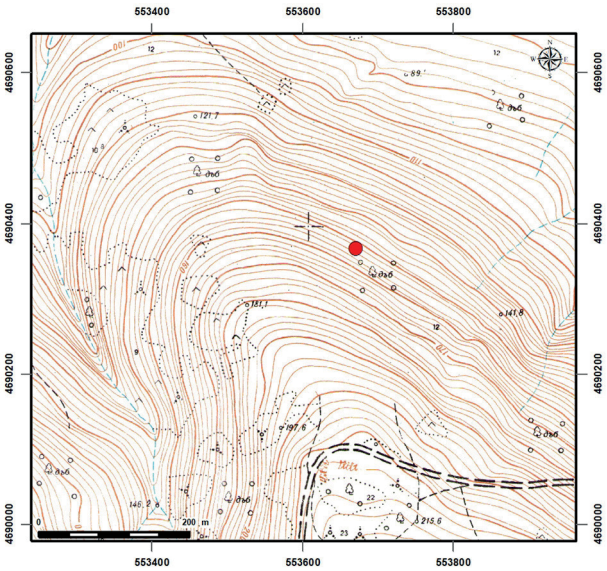

Fig. 178. Location of a group of small stone tumuli at the Ravadinovo 2 site.

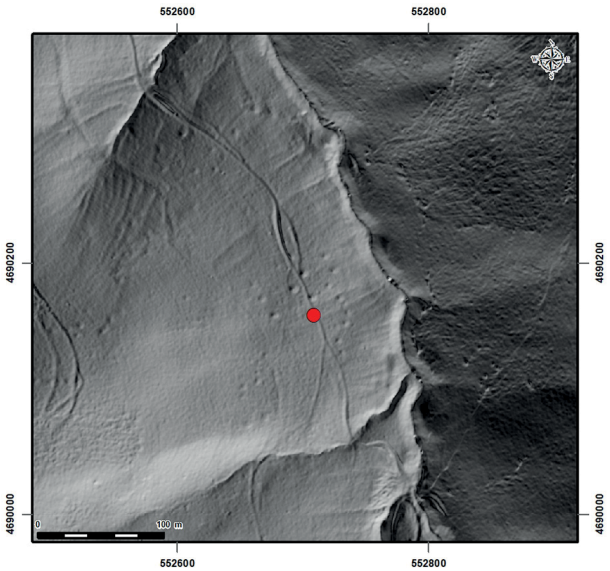

Fig. 176. Surface structure of a small group of stone tumuli Ravadinovo 1 on the LiDAR record.

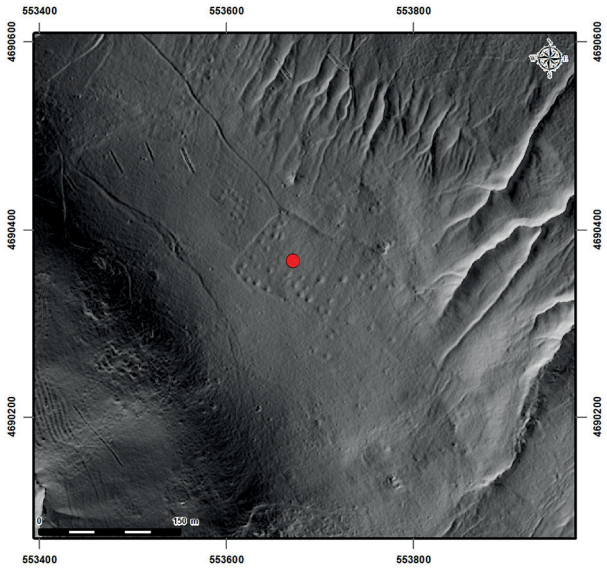

Fig. 179. Surface structure of a group of small stone tumuli Ravadinovo 2 on the LiDAR record.



Fig. 177. Small stone tumulus from the Ravadinovo 1 group.



Fig. 180. Small stone tumulus from the Ravadinovo 2 group.

55. Small 'Stone Mounds' Ravadinovo 1
35T 552709 4690158

(a) The site is located 3230m south-west from the centre of Ravadinovo village, Sozopol municipality. It is situated 128m to 160m above sea level, on the upper sector of the steep (more than 25°) east slope of Medni Rid, on the left bank of a shallow ravine 570m north-east of the Veselie 2 burial site (*fig. 175*).
(b) According to data from a LiDAR survey there are more than 30 positive terrain forms of similar dimensions on an area of about 4ha and it is clear that in the lower part of the slope near the ravine the structures are much more densely arranged (*fig. 176*). Twenty-one of them were visited. All are small mound-like structures of small and mid-sized rough stone blocks, 4m to 5m in diameter and 0.3m to 0.6m high (*fig. 177*). Treasure hunter's ditches were not registered, nor archaeological artefacts found. The function and the cultural affiliation of these structures remain unclear.
(e) Unclear.
(f) Survey 2015.

56. Small 'Stone Mounds' Ravadinovo 2
35T 553671 4690367

(a) The site is located 2480m south-west from the centre of Ravadinovo village, Sozopol municipality 150m to 170m above sea level located in the central sector of the north-east slope of Medni Rid (*fig. 178*). The terrain is wooded.
(b) According to data of a LiDAR survey, in an area of about 1.7ha more than 30 positive terrain forms of similar dimensions on a gentle slope have been detected. Compared with other similar complexes these (*fig. 179*) mound-like structures are arranged much more tightly. Twelve structures were visited. All of them are made of small and mid-size rough stone blocks, 4m to 6m in diameter and 0.5m to 0.8m high (*fig. 180*). Treasure hunter's ditches were not registered, nor archaeological artefacts found. To the north-west, the complex of mound-like structures is surrounded by a linear stone structure with a height of 0.5m, 73m long with a width of about 1.5m. The stone structure makes a curve at its south-western end and can further be traced over 25m in south-east direction. The function and the cultural affiliation of the complex and its structures remain unclear.
(e) Unclear.
(f) Evaluation of LiDAR data.

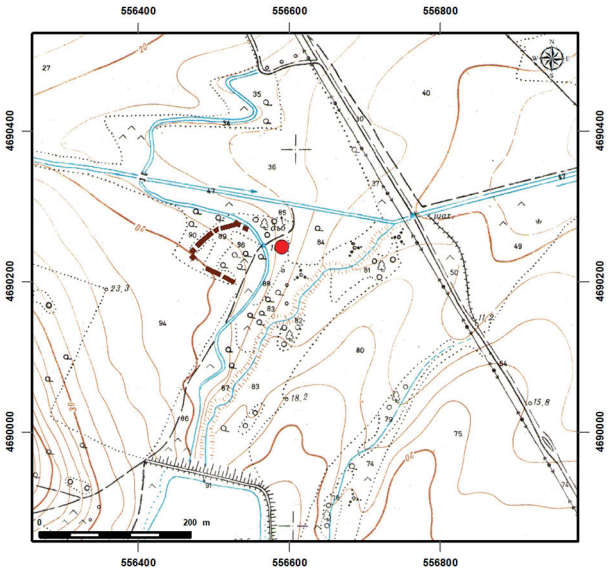

Fig. 181. Location of the settlement and burial mound Dobrovitsa.



Fig. 182. Destroyed masonry brick grave in the Dobrovitsa mound.

57. Dobrovitsa Settlement (?) and Burial Mound
35T 556534 4 90234 (Settlement)
35T 556591 4690246 (Tumulus)

(a) The site is located 6350m south-west from the building of Sozopol municipality. It is located 12m to 20m above sea level, at the foot of the Misiryata hill, on a terrace slightly sloping to the east above the catchment of two small streams (*fig. 181*). The terrain is overgrown with bush and tree vegetation.



Fig. 183. Pottery fragments from the Greek Classical period from the destruction at the base of the Dobrovitsa mound.

(b) The site covers an area of 1.4ha and consists of two elements: traces of a settlement and a tumulus. On the terrain, an enclosure made of rough stone blocks and of a U-like irregular shape is covering an area of 0.4ha. The dimensions of the segments of the enclosure traced counter-clockwise from the north-east are 20m and 40m, and from the south-west 43m. The structure is made of mid-size and large rough stone blocks fallen from walls with a width of up to 5m and a height of 0.5m to 1m. At some spots, the faces of the wall are still visible. Two of the collapsed stone settings are cut by a cart road leading to the Gabera dam. One to two rows of well-arranged stones preserved *in situ* could be observed in the profiles. Along the bed of the cart roada few fragments of wheel-made pottery were found. Numerous small treasure hunter's ditches can be observed on the surface of the site. There are records that large pieces of slag were collected on the site in the past. However, during visits on site, such were not detected probably due to poor visibility. The tumulus is about 40m east outside the stone enclosure. It is 16m in diameter and 1m high. Most of it was destroyed by a large treasure hunter's ditch more than 50m^2 in size. Some mid-sized rough stone blocks were tightly arranged in place around the steps of the tumulus. Remains of a destroyed grave structure made of bricks and fixed with mortar were registered in the south-west profile of the large treasure hunter's ditch (*fig. 182*). The dimensions of the preserved part of the brick structure are 0.95m wide and 0.55m high. The bricks used are 0.32m by 0.16m by 0,04m in size. The brickwork is oriented east/west and was dug into a very shallow depth. Probably it dates later than the original tumulus. At the bottom of the large ditch there is a second trench with a length of 1.5m, a width of 0.4m and a depth of 1m. A layer composed of coal and ashes appears in the profile of the latter at a depth of 0.4m. This layer might be associated with the primary burial of the tumulus or relates to the periphery of the settlement, which the tumulus overlaps. The treasure hunter's ditches contain numerous fragments of handmade and wheel-made pottery (*fig. 183*).

(e) Settlement: Classical Greek period; tumulus: Roman period, Late Roman period.

(f) Survey 2016.

(g) Лещаков et al. 2017a, 716.

58. Malkoto Kale Fortress and Burial Site
35T 556113 4687567 (Fortress)
35T 555996 4687567 (Burial Site)

(a) The site is located 9050m south-west from the Sozopol municipality building in the southern

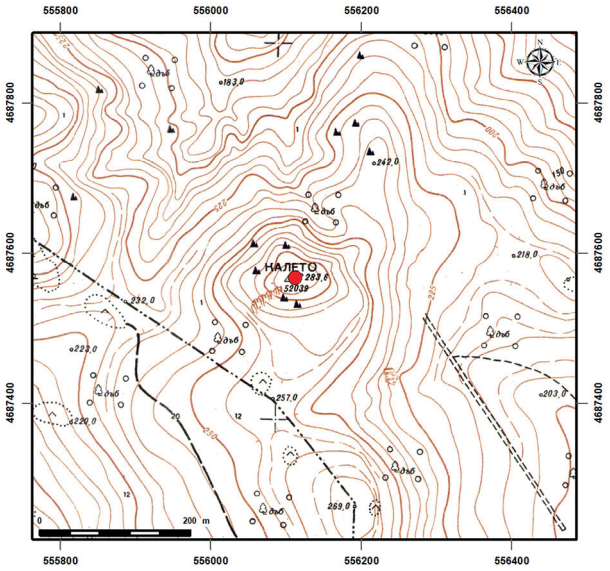

Fig. 184. Location of the Malkoto Kale fortress.



Fig. 185. Entrance to the Malkoto Kale fortress.



Fig. 186. Round stone encircling uncovered in one of the excavated tumuli next to Malkoto Kale.

area of the Medni Rid chain 284m above sea level, on the flat plateau-like Kaleto height (*fig. 184*). The peak has steep slopes, with access from the south-west through a saddle. The fortress has a good view to the sea coast in the east and north-east. The terrain is wooded.

(b) The fortress wall surrounds an area of 0.2ha of irregular polygonal shape over the flat top of the peak. It includes large natural stones and protruding bedrock. The wall is made of mid-sized and large rough stone blocks in dry masonry connecting and complementing the large natural rocks and forming an impressive fortification. The average wall thickness is about 2.5m. The entrance from the south-west is arranged between two large boulders (*fig. 185*). At the southern foot of the fortress, on a slightly sloping terrace, remains of a settlement were observed, marked by clusters of stones, numerous amphora and household ware sherds and fragments of architectural terracotta. The fortress was studied archaeologically in the years from 1972 to 1978. Four periods of habitation were registered. The earliest one relates to the Early Iron Age and contains artefacts from the 9th to 6th cent. BC. Some houses of wattle and daub construction were revealed. The second period of habitation in the fortress is from the 6th to 5th cent. BC. The pottery found within the cultural layer was mostly handmade, although some fragments of imported black-glazed vessels are also present. The third cultural layer dates from the late 4th to mid-2nd cent. BC. The researchers consider that at this time the fortress became a part of the Apollonia *chora*. The main fortification was constructed, and the lower settlement also developed. The Hellenistic layer contained fragments of slag, a casting mould and a blower nozzle testifying to metallurgical activities carried out on-site. The end of this period is marked by a coin of Mithridates VI Eupator, king of Pontus and probably coincides with the conquest of the Apollonia coast by Marcus Lucullus in 72 BC. The latest habitation of Malkoto Kale is documented by artefacts from the early Byzantine period, 4th to 6th cent AD. Buildings marked by walls of rough stone blocks and burial sites of the fortress were registered about 180m south and south-west of the fortress along the terrain of the saddle and the western slope. Two tumuli were explored. They were found to be made of earth with stone circles around them (*fig. 186*). The tumuli and the stone circles contained burials from the Hellenistic period. In 1977 a complex of stone structures was

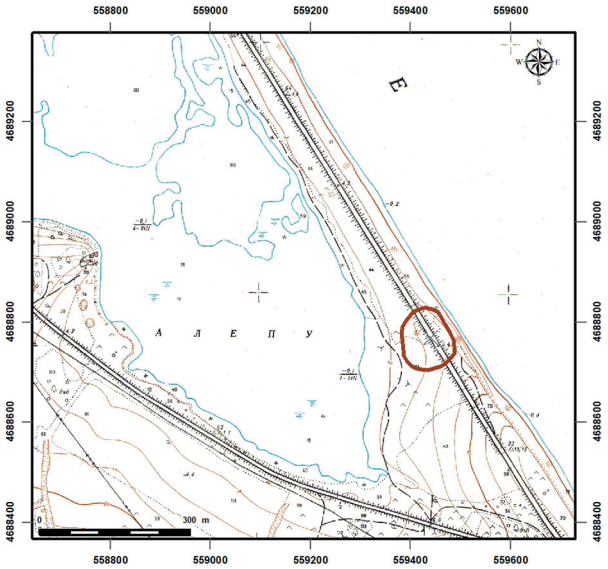

Fig. 187. Location of the prehistoric site Alepu.



Fig. 188. Prehistoric settlement Alepu, view from the north-west.



Fig. 189. Pieces of copper ore from the prehistoric settlement Alepu.

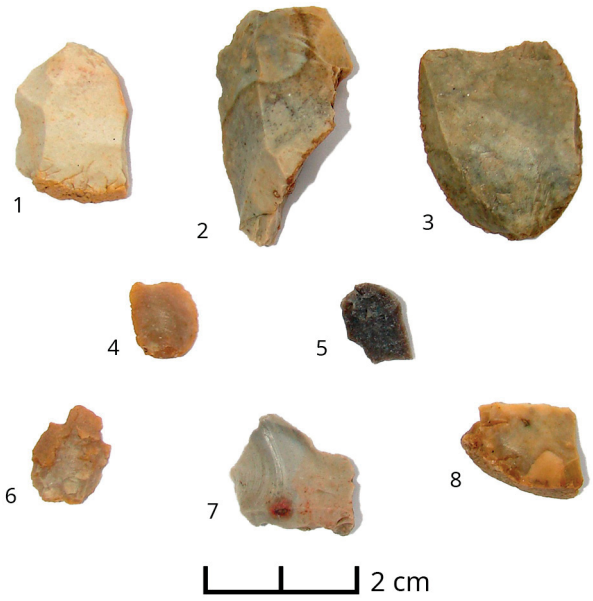

Fig. 190. Chipped stone artefacts from the prehistoric settlement Alepu.

registered north of the fortress. During the next year, five small stone mounds of this complex were studied but burials were not found. One of them contained fragments of pottery made on a potter's wheel. The function and the precise date of the structures and the complex, in general, remained unclear. The numerous small mounds at the foot of the Malko Kale fortress are similar to the complexes of stone structures registered elsewhere in the Medni Rid area (cat. nos. 29, 39, 54, 55 and 56) whose purpose and function also remain unclear.
(e) Early Iron Age, Classical Greek and Hellenistic periods, early Byzantine period.
(f) Survey 2016.
(g) Шкорпил/Шкорпил 1891, 145; Гоцев et al. 1992, 29–42; Делирадев 1953, 81; Венедиков et al. 1976, 31–33; 1978, 49 f.; 1979, 64 f; Венедиков/Фол 1976, 131–155; Венедиков et al. 1979; Фол 1982, 360–378; Делев 1990, 143; Domaradski et al. 1991, 119–132; Домарадски et al. 1992, 29–42; Лещаков/Димитров 2017, 713.

59. Alepu Settlement
35T 559441 4688768

(a) The site is located 8140m south-east from the Sozopol municipality building. It is situated 1m to 7m above sea level, located below the sand of the coastal dune about 20m away of the contemporary coastline between the Alepu marsh and the southern end of the beach of the same name



Fig. 191. Late Neolithic potteryfragments from the prehistoric site Alepu.

(*fig. 187*). The site is located on a terrace facing north-west and rising in south-east direction, crossed by the old asphalt road from Sozopol to Primorsko (*fig. 188*). In severe sea storms, the waves reach it and gradually destroy the archaeological site.

(b) Scattered tiny fragments of burnt daub, pieces of copper ore (*fig. 189*), small flint artefacts (*fig. 190*) and pottery fragments (*fig. 191*) from late prehistory appear between the asphalt road and the beach on an area of about 0.2ha. A cultural layer, greyish brown in colour, containing dispersed pottery fragments and *in situ* remains of a hearth or furnace, ash and charcoal was observed parallel to the seashore in the natural profile shaped by the marine abrasion. The layer is lying above yellow clay ground and is covered with sandy soil and sand. The cultural layer bears traces of habitation during late prehistory. The north-east sector of the zone containing prehistoric artefacts is intersected by three or four parallel rectangular trenches oriented east/west. They were dug into the cultural layer and filled with sand. The trenches are similar to the trenches explored in other places on the territory of Apollonia Pontica and interpreted as traces of ancient agricultural activities.

(e) Late Neolithic, Greek and Roman periods.

(f) Surveys 2011, 2014.

(g) Лещаков 2013, 572–574; Лещаков et al. 2016d, 944–948.

60. Fortress Chivridzhika 35T 559529 4685316

(a) The site is located 6240m north-west from the Primorsko municipality building 89m above sea level on a small rocky height along the east slope of Medni Rid (*fig. 192*) and along the left bank of the Ropotamo river. One of the river's crossings within its lower course is situated nearby.

(b) On the high, flat top of the peak there are remains of stone walls, enclosing a regular rectangle of an area of about 800m^2 with a length of 30m in north-east/south-west direction of and of 26m in north-west/south-east direction. The wall was erected with mid-sized rough stone blocks, including also protruding bedrock. The width of the wall is more than 3m and the thickness 1.3m to 1.5m (*fig. 193*). In the interior of the fortress no cultural layer was observed, as the terrain is exposed down to the bedrock. In the eastern direction, the fortress has a visual connection with Valchanovo Kale fortress, located at a distance of 1100m above the opposite bank of the Ropotamo river. According to the plan, technique of construction and topographic location, the fortress of Chivridzhika is similar to the Oshileno Bairche fortress (site 34).

(e) Unclear.

(f) Survey 2016.

(g) Даскалов/Прахов 2012, 573 f.; Лещаков/Димитров 2017, 713.

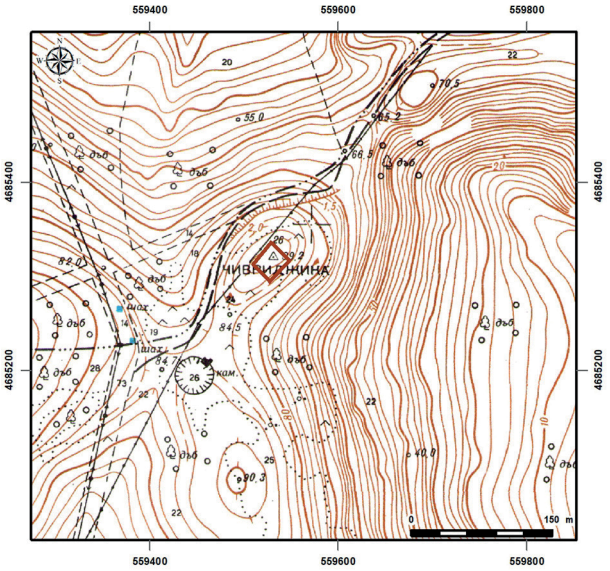

Fig. 192. Location of the Chivridzhika fortress.

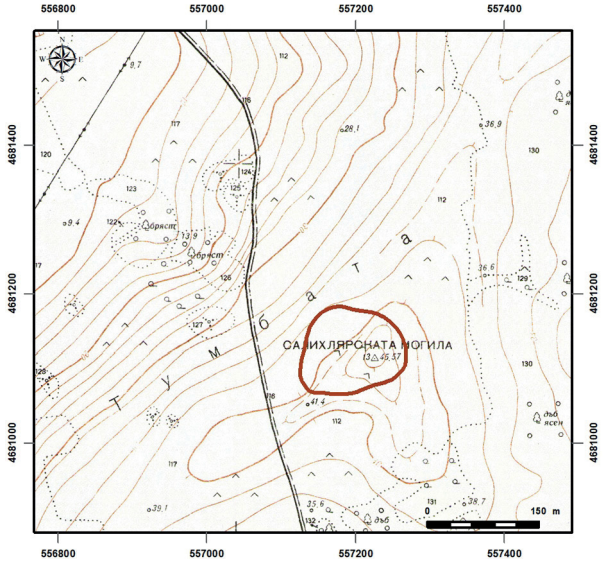

Fig. 194. Location of the settlement and burial mound at the Salihlyar site.



Fig. 193. Stone remains of the north-western fortification wall of the Chivrizhdika fortress.



Fig. 195. Settlement and burial mound at the Salihlyar site, view from the south-west.

61. Settlement and Tumulus Salihlyarskata Mogila
35T 557224 44 681122 (Settlement)
35T 557228 4681115 (Tumulus)

(a) The site is located 5250m north-west from the Primorsko municipality building 38m to 45m above sea level on the flat hill , 840m away from the right bank of the Ropotamo river (*fig. 194*). The terrain is arable, crossed by a dirt road running north/south through the western periphery of the site (*fig. 195*).

(b) The site represents a settlement from the late prehistory and a tumulus built on top of it. Artefacts from the 18th to 19th cent. AD appear along the western slope of the elevation probably belonging to a Circassian village known from historical sources. Fragments of handmade and wheel-made pottery, respectively relating to the late prehistory and the Ottoman period, were found in an area of 1.3ha (*fig. 196*). The earlier artefacts are concentrated mainly in the eastern sector of the area next to the tumulus. On the surface, secondarily fired fragments of daub appear as well as stone and flint artefacts (*fig. 197–198*), and fragments of handmade pottery. The tumulus consists of accumulated greyish black soil containing a high concentration of pieces of daub and prehistoric handmade pottery. Its diameter is 30m and its height about 1.5m. In 2013 an old treasure hunter's trench was observed and scattered human bones and modern artefacts found at its bottom. Few human bones were also found west of the dirt road. They probably come from burials destroyed during agricultural processing.

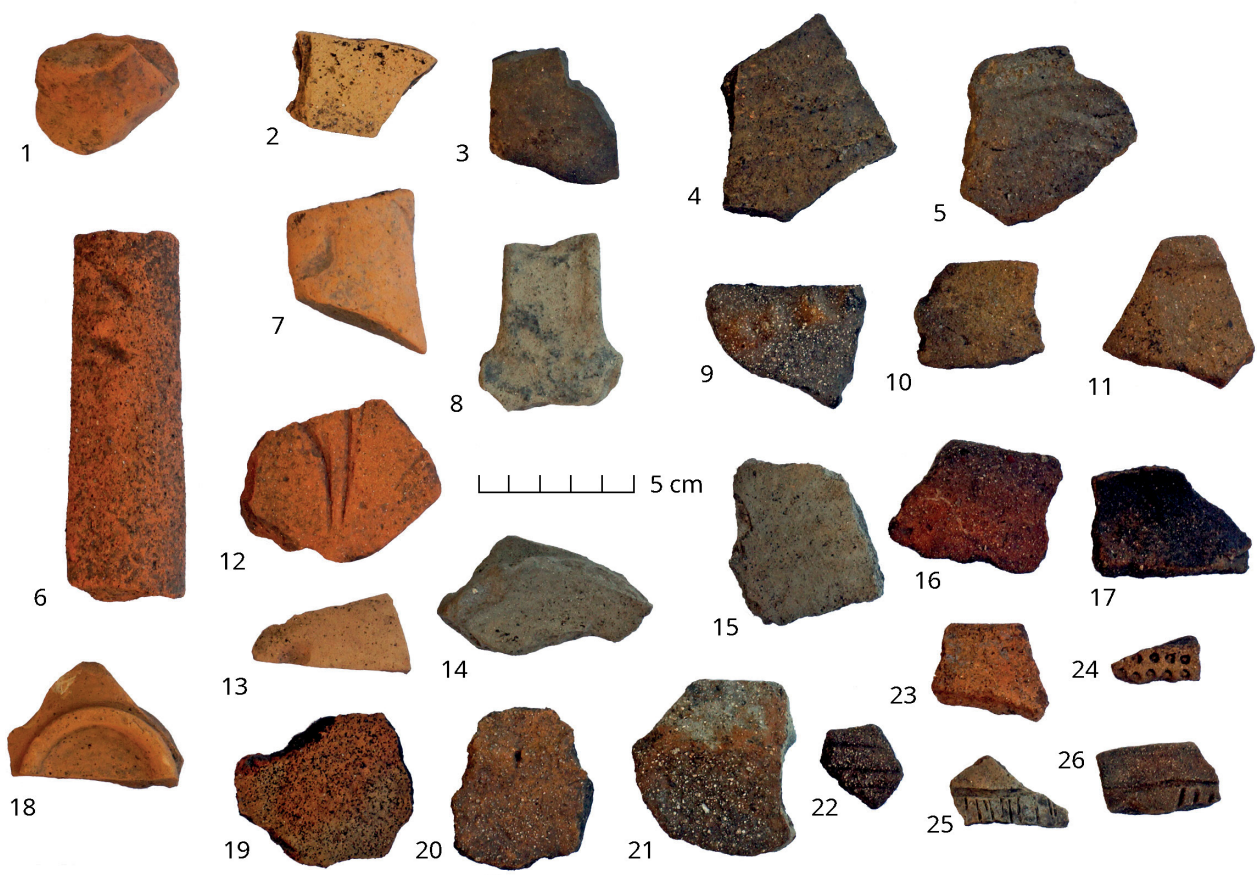

Fig. 196. Late Neolithic, Antique and Ottoman pottery fragments from the settlement at the Salihlyar site.



Fig. 197. Late Neolithic stone tools from the settlement at the Salihlyar site.

(e) Late Neolithic, Greek and Roman periods, Ottoman period.
(f) Surveys 2013, 2015.
(g) Балабанов 2013, 190; Лещаков et al. 2016a, 880.



Fig. 198. Prehistoric chipped stone artefacts from the settlement at the Salihlyar site.

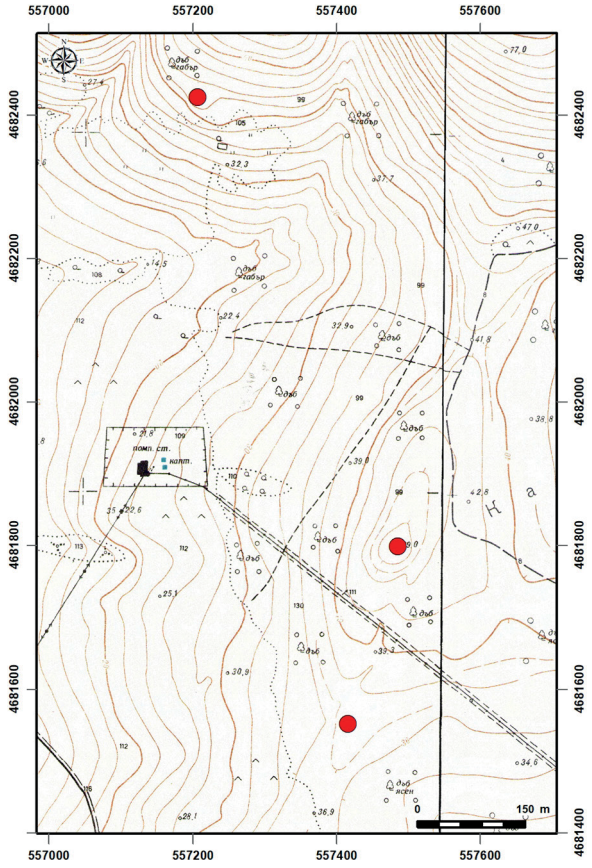

Fig. 199. Location of the tumulus necropolis at the Salihlyar site.



Fig. 200. Northern burial mound from the tumulus necropolis Salihlyarskata mogila, view from the south.



Fig. 201. Bronze dagger uncovered in the northern burial mound (after Балабанов/Пантов 2018, обр. 3).

62. Burial Site Salihlyarskata Mogila 35T 557456 4681652

(a) The site is located 5200m north-west from the Primorsko municipality building 37m to 49m above sea level, located over the ridge of a low hill and its southern slope (*fig. 199*), at a distance of 420m from the Salihlyarskata Mogila (site 61). The terrain is wooded.

(b) The burial site consists of two tumuli 250m apart. The southern tumulus is about 20m in diameter and 2.5m high. It is destroyed by a treasure hunter's trench. The mound was accumulated from soil, light whitish in colour, and mid-size rough stone blocks in its upper part. No archaeological artefacts were found on site. The second tumulus is located 250m north-east of the first one. It is 25m in diameter and 3m high (*fig. 200*). Its central part and periphery are destroyed by numerous treasure hunter's trenches. The mound was accumulated from soil, light whitish in colour, and contains mid-size rough stone blocks in its upper part. No archaeological artefacts were found on-site during the visit in 2015. In 2017 the tumulus was partially explored by P. Balabanov and D. Pantov. Two stages of accumulation were established. A stone structure of unclear function was revealed at its base. A layer of coal and traces of combustion associated with the stone structure were discovered. A bronze dagger (*fig. 201*) and a jug dating to the Bronze Age were found in a secondary burial. A third mound on the southern slope, 680m north-west of the northern tumulus, was investigated in 2016 by P. Balabanov and D. Pantov. It measures 124m by 86m and is 6,4m high. The tumulus contained a destroyed rectangular grave structure oriented according to the cardinal points. The structure was built of rectangular well-shaped stones (*quadrae)*. The floor had a mortar coating on a padding of pottery fragments. A part of a horse's hoof and hobble were found in the north-east corner of the stone structure. Below the floor of the structure a hoard containing 40 golden elements of a horse's decorated



Fig. 202. Golden items from a horse bridle uncovered during the excavations at the northern mound of the tumulus necropolis (after Балабанов/Пантов 2017, обр. 3).

harness was discovered (*fig. 202*). A ceramic lamp dating from the late 4th to early 3rd cent. BC was also found near the artefacts described above. A silver handle of a vessel, a fragment of a bronze appliqué and a bronze nail were found in the eastern periphery of the tumulus. Three areas with a concentration of amphora fragments and imported and local table pottery were explored in the south-west sector of the tumulus. The amphorae came from Thasos, Chios, Mende, Peparethus and Sinope. They are dating from the second half of the 4th to the early 3rd cent. BC.

(e) Early Hellenistic period.

(f) Archaeological research 2015, 2016.

(g) Лещаков et al. 2016a, 880; Балабанов/Пантов 2017, 210–213; 2018, 85–88.

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René Kunze and Ernst Pernicka

Pre-Industrial Mining in Medni Rid

Geochemical Analyses

Keywords: Bulgaria, Medni Rid, trace elements, lead isotopes, Akladi Ceiri

Morphological and Geological Setting[1]

The ore mineralisations of the localities under study are manifold but are predominantly oxidised. They occur as hydrothermal veins which infiltrate the surrounding rock through a structural weakness zone. A strong alteration – that is, a physicochemical change in the adjacent rock – goes along with this most of the time. This can be noted by visible changes ranging from changes in colour and consistency to a complete overprint of the original rock fabric. The ore bodies are steeply and subvertically lying linear structures with a thickness ranging from a few centimetres to several metres. Most veins in Medni Rid strike roughly in a north-east/south-west direction as well as east/west, therefore crossing over the ridge running north/north-west to south/south-east respectively north/south at a right angle. In the field, the remains of ore bodies can be recognised by their characteristic ochre hue which is bleached in colour sometimes either orange or light grey/white. This discolouration can also be recognised in the rocks surrounding the ore bodies over several metres.

Also noticeable are turquoise and greenish/blue smaller veins and efflorescences which run through the rock (*fig. 1*). These fine veins often appear glassy or amorphous. Judging from their colours they seem to consist of secondary copper minerals that could be either copper carbonates (malachite, azurite), copper sulphates (e.g. chalcanthite) or copper silicates (chrysocolla), all of which comprise a large group of chemically variable minerals. Due to their small size, a macroscopic differentiation is difficult. The glassy appearance and the colour could indicate, for instance, chrysocolla. Qualitative analyses using pXRF suggest the presence of copper sulphates in specific areas.

Samples

Altogether fist-sized ore samples from various mineral occurences[2] (not deposits) in the Medni Rid area[3] and from four deposits (!) from the surrounding hinterlands[4] (*fig. 2*) were investigated using a double-focusing mass spectrometer with inductively-coupled plasma excitation (Neptune Plus HR-MC-ICP-MS) for the measurements of the lead isotope ratios as well as instrumental neutron activation analysis (INAA) for the determination of trace element concentrations, all carried out at the Curt-Engelhorn-Center for Archaeometry gGmbH in Mannheim, Germany. All sampling localities were documented and coordinates were noted (*table 1*).[5] In addition, four deposits from the Balkan-Carpathian metallurgical complex that

1 See Rödel, this volume, 297–306.

2 A mineral occurence describes a locality where a mineral is found but without any resource implication on size or exploitability such as a deposit.

3 Propadnala Voda, Medni Rid Mt., Surneshko Kladenche, Kyumyurlaka, Rosen Ore Field.

4 Varli Bryag, Zidarovo, Zelenata Kanara (Silistar).

5 See Kunze et al., this volume, 307–326.



Fig. 1. The gangue and ore mineralisation of Varli Bryag (left). Altered rock with secondary copper minerals and iron oxides from Propadnala Voda (right).

have been shown to have been exploited during prehistoric times were also included.[6] Published data were used for comparison and only Ai Bunar (near Stara Zagora in central Bulgaria) – as we did in Varli Bryag and Zidarovo near Medni Rid – was verified using our own samples and analyses.

Each ore sample was photographed and then crushed in order to remove gangue material and barren host rock, while the ore minerals were concentrated and finely ground in a ball mill (*figs. 3–4*) The powdered sample was homogenised and split into aliquots for the different analytical methods.

The archaeological samples from Akladi Cheiri, Budzhaka, and Alepu (Leshtakov 2013; Leshtakov et al., this volume, 89–120) consisted mainly of pieces of ore from various pits ranging in date from Late Neolithic to Late Chalcolithic. In the excavation of Akladi Cheiri (*fig. 5*) as the most interesting find spot the Late Neolithic (Karanovo III/IV) is represented by more than 40 ash- and clay-filled pits with numerous finds of ceramic vessels, tools of bone, stone, and flint as well as a few pieces of copper ore (mostly malachite) mainly in pits 20, 45 and 68. The chalcolithic period is represented by a large number of copper ores (mainly in pits 4, 9 and 13 for the Early/Middle Chalcolithic [Karanovo V/VI] and pit 28 for the Late Chalcolithic Kodžadermen-Gumelniţa-Karanovo VI Complex (KGK VI) and evidence of copper smelting and producing of artefacts such as a copper awl in pit 54 (Leshtakov 2013). One copper prill (No 5, sample MA-151990) from a metallurgical slag (see Rehren et al. 2016, 209), the ceramic fabric and adhering slag from a crucible (No 68, MA-133048 [slag] and No 69, MA-133049 [ceramic]) from pit 28 were also analysed. Both are dealt with in more detail in Rehren et al. (this volume). Another piece of copper most likely derived from the Thracian period (6th cent. BC) at Akladi Cheiri (No 70, MA-133050) and was handed over at the museum in Sozopol. In the field survey copper slag was encountered at two sites (Propadnala Voda and Kyumyurluka) on the surface and is, accordingly, not dated but was included in the analytical study, because these samples would irrespective of their dating provide lead isotope ratios after smelting and would thus indicate any changes due to the technological processes.

Finally, powdered samples of copper-rich material from two Late Neolithic sites in southeastern Bulgaria where copper ore (mainly malachite) was found were made available by K. Dimitrov. Hadzhidimitrovo is a large prehistoric site located 13km north-west of Yambol. Over an area of more than one hectare more than 250 pits were investigated (Petrova et al. 2016). Abundant pottery finds indicate that the site was mainly occupied during the Karanovo IV period, ca. 5300 to 4900 BC (Görsdorf/Bojadžiev 1996). Several fragments of copper minerals, mainly malachite, were

6 These include the west Balkan copper deposits at Maidanpek, Rudnik and Bor in Serbia as well as the ore deposit at Ai Bunar in northern Thrace located in present-day central Bulgaria.

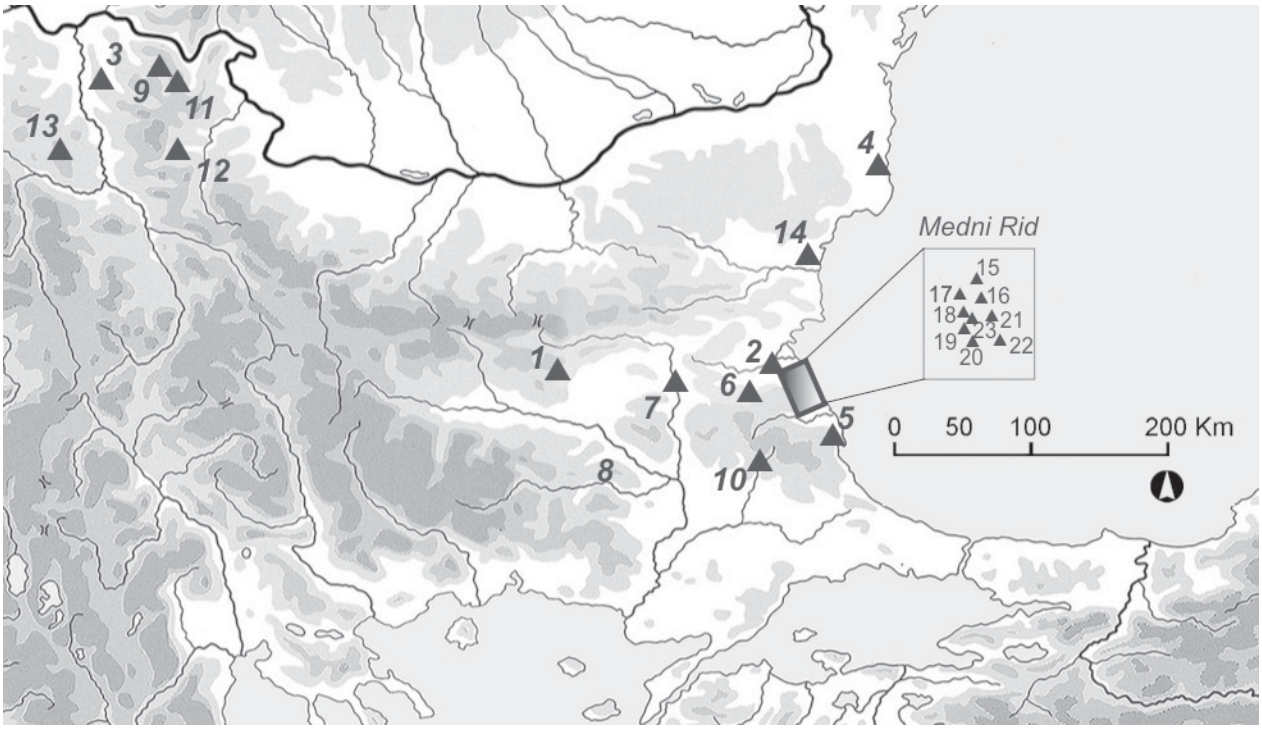


Fig. 2. Map of the sites mentioned in the article: 1 Ai Bunar, 2 Varli Bryag, 3 Belovode, 4 Durankulak, 5 Zelenata Kanara (Silistar), 6 Zidarovo, 7 Hadzhidimitrovo, 8 Dana Bunar 2, 9 Maidanpek, 10 Dereköy, 11 Rudna Glava, 12 Bor, 13 Rudnik, 14 Varna, 15 Atiya, 16 Akladi Cheiri, 17 Rosen Ore Field, 18 Kyumyurlaka, 19 Surneshko Kladenche, 20 Propadnala Voda, 21 Budzhaka, 22 Alepu, 23 Medni Rid Mt. For the exact localisation and description of the find spots in Medni Rid, see Kunze et al., this volume, 307–326.

recovered. Their mineralogical composition with intergrowth of malachite with garnet and diopside was interpreted as indicating a provenance from the copper deposit at Prohorovo, some 50km to the east of Ai Bunar and some 25km southwest of Yambol. Numerous traces of ancient mining are known that resemble those at Ai Bunar. Surface finds of chalcolithic pottery suggest that this area may have also been exploited during the 5th mill. BC but no excavations have been performed so far. However, Prohorovo is a porphyry copper deposit that is characterised by a large amount of low-grade copper.

Nevertheless, it is conceivable that some enriched copper ores occurred in the oxidation zone of the deposit near the surface. The site of Dana Bunar 2 near Lyubimets was excavated by V. Nikolov and revealed two cultural layers dating to the Karanovo III–IV and Karanovo IV periods. This site, as well as Hadzhidimitrovo, were interpreted by Nikolov (2011) as late Neolithic pit sanctuaries. A piece of copper ore ('a common feature in Late Neolithic sanctuaries in Thrace' [Nikolov 2011]) was found in one pit at Dana Bunar 2, and the sample MA-152460 (No 55) was probably taken from this piece.

The hilly landscape of Medni Rid has been exploited since antiquity due to its wealth in raw materials. Ancient mining has left features like depressions, ore pits and mining trenches in the region which are morphologically easily distinguishable from their natural surroundings. The superficially visible traces of old mining activity often have the appearance of ditches or trenches due to the subvertical structure of the ore bodies which run linearly below the surface. Besides the relatively imposing, partially 15m wide and 3m deep, mining trenches there are also round forms with various diameters which are most likely collapsed shafts indicating locally-confined underground activity or experimental mining activity.[7] An extensive and involved excavation of a mining

7 For standard terminology see the chapter on methodology of Kunze et al., this volume, 307–326.

No.	Lab no.	Orig. ID	Material	Site	Context I	Context II	Relative Chronology
1	MA-135447	1	Slagged crucible wall with malachite	Akladi Cheiri	Settlement	Pit 28, Sq: H20/ G20; Layer: 1	Late Chalcolithic, Karanovo VI
2	MA-135448	2	Malachite	Akladi Cheiri	Settlement	Pit 28, Sq: H20/ G20; Layer: 1	Late Chalcolithic, Karanovo VI
3	MA-135449	3	Malachite	Akladi Cheiri	Settlement	Pit 52, Sq: O15; Layer: 1	Late Chalcolithic, Karanovo VI
4	MA-135450	4	Malachite	Akladi Cheiri	Settlement	Pit 64, Sq: N12/ N13; Layer: 1	Late Chalcolithic, Karanovo VI
5	MA-151990	5	Copper prill (crucible)	Akladi Cheiri	Settlement	Pit 28, Sq: H20/ G20; Layer: 1	Late Chalcolithic, Karanovo VI
6	MA-135451	6	Malachite	Budzaka	Settlement	Sq: C3	Late Neolithic
7	MA-135452	7	Malachite	Alepu	Settlement	Surface	Late Neolithic/ Early Chalcolithic
8	MA-135453	8	Malachite/ azurite	Varli Bryag	Mineral-isation	Copper deposit, surface finds	
9	MA-135454	9	Malachite	Rosen ore field	Mineral-isation	Copper deposit, ancient mine	
10	MA-135455	10	Malachite	Atiya	Metallurgi-cal site	Metallurgical site	
11	MA-141987	11	Malachite	Zidarovo	Mineral-isation	Copper deposit, ancient mining trench	
12	MA-141988	12	Malachite/ azurite	Varli Bryag	Mineral-isation	Copper deposit, surface finds	
13	MA-141989	13	Malachite	Propadnala Voda	Mineral-isation	Copper deposit, surface finds	
14	MA-141990	14	Malachite	Rosen ore field	Mineral-isation	Copper deposit, surface finds	
15	MA-141991	15	Malachite	Aibunar	Mineral-isation	Copper deposit, surface finds	
19	MA-141992	16	Malachite	Zelenata kanara	Mineral-isation	Copper deposit, surface finds	
21	MA-145532	19	Malachite	Rosen ore field	Mineral-isation	Copper deposit, surface finds	
22	MA-145533	20	Malachite	Propadnala Voda	Mineral-isation	Copper deposit, surface finds	
23	MA-145534	21	Slag	Propadnala Voda	Mineral-isation	Copper deposit, surface finds	
24	MA-147715	22	Malachite	Propadnala Voda	Mineral-isation	Copper deposit, surface finds	
25	MA-147716	23	Malachite	Propadnala Voda	Mineral-isation	Copper deposit, surface finds	
26	MA-147717	24	Malachite	Medni Rid mt.	Mineral-isation	Copper deposit, surface finds	
28	MA-147718	25	Malachite	Propadnala Voda	Mineral-isation	Copper deposit, surface finds	

No.	Lab no.	Orig. ID	Material	Site	Context I	Context II	Relative Chronology
29	MA-147719	26	Malachite	Kyumyurlaka (mine)	Mineralisation	Sunken shaft	
30	MA-147721	28	Malachite	Kyumyurlaka (smelting)	Metallurgical site	Smelting site	Bronze Age (?)/ Antiquity
37	MA-147722	29	Malachite	Propadnala Voda	Mineralisation	Copper deposit, surface finds	
53	MA-147723	30	Malachite	Surneshko Kladenche	Mineralisation	Copper deposit, mining trenche	
54	MA-152442	37	Malachite	Propadnala Voda	Mineralisation	Copper deposit, surface finds	
55	MA-152458	53	Malachite	Hadzhidimitrovo	Settlement	Sq. C0, feat. 52	Late Neolithic
56	MA-152459	54	Malachite	Hadzhidimitrovo	Settlement	Sq. G11, Feat. 37	Late Neolithic
57	MA-152460	55	Malachite	Lubimets-Dana Bunar 2	Settlement	Sq. B15, Feat. 108	Late Neolithic
59	MAMS-24609	56	Slag/ charcoal	Kyumyurlaka (smelting)	Metallurgical site	Smelting site, wood in copper slag	Early Bronze Age
61	MAMS-27894	57	Slag/ charcoal	Kyumyurlaka (smelting)	Metallurgical site	Smelting site, wood in copper slag	Antiquity (Roman period)
62	MA-133042	Ac 67	Malachite	Akladi Cheiri	Settlement	Swimming pool site	Middle-Late Chalcolithic
63	MA-133043	Ac 69	Malachite	Akladi Cheiri	Settlement	Swimming pool site	Late Neolithic
64	MA-133044	Ac 70	Malachite	Akladi Cheiri	Settlement	Swimming pool site	Late Neolithic
65	MA-133045	Ac 110	Malachite	Akladi Cheiri	Settlement	Pit 20	Late Neolithic, Karanovo III/IV
66	MA-133046	Ac 116	Limonite/ malachite	Akladi Cheiri	Settlement	Pit 28	Late Chalcolithic, Karanovo VI
67	MA-133047	Ac 118a	Limonite/ malachite	Akladi Cheiri	Settlement	Pit 28	Late Chalcolithic, Karanovo VI
68	MA-133048	Ac 119b	Crucible/ ceramic, adhering slag	Akladi Cheiri	Settlement	Pit 28	Late Chalcolithic, Karanovo VI
69	MA-133049	Ac 119b	Crucible/ ceramic, ceramic material	Akladi Cheiri	Settlement	Pit 28	Late Chalcolithic, Karanovo VI
70	MA-133050	SoMu	Copper	Akladi Cheiri?	Settlement	Sample from Sozopol museum	Thracian period (6th cent. BC)

Table 1. Overview of the analysed samples.

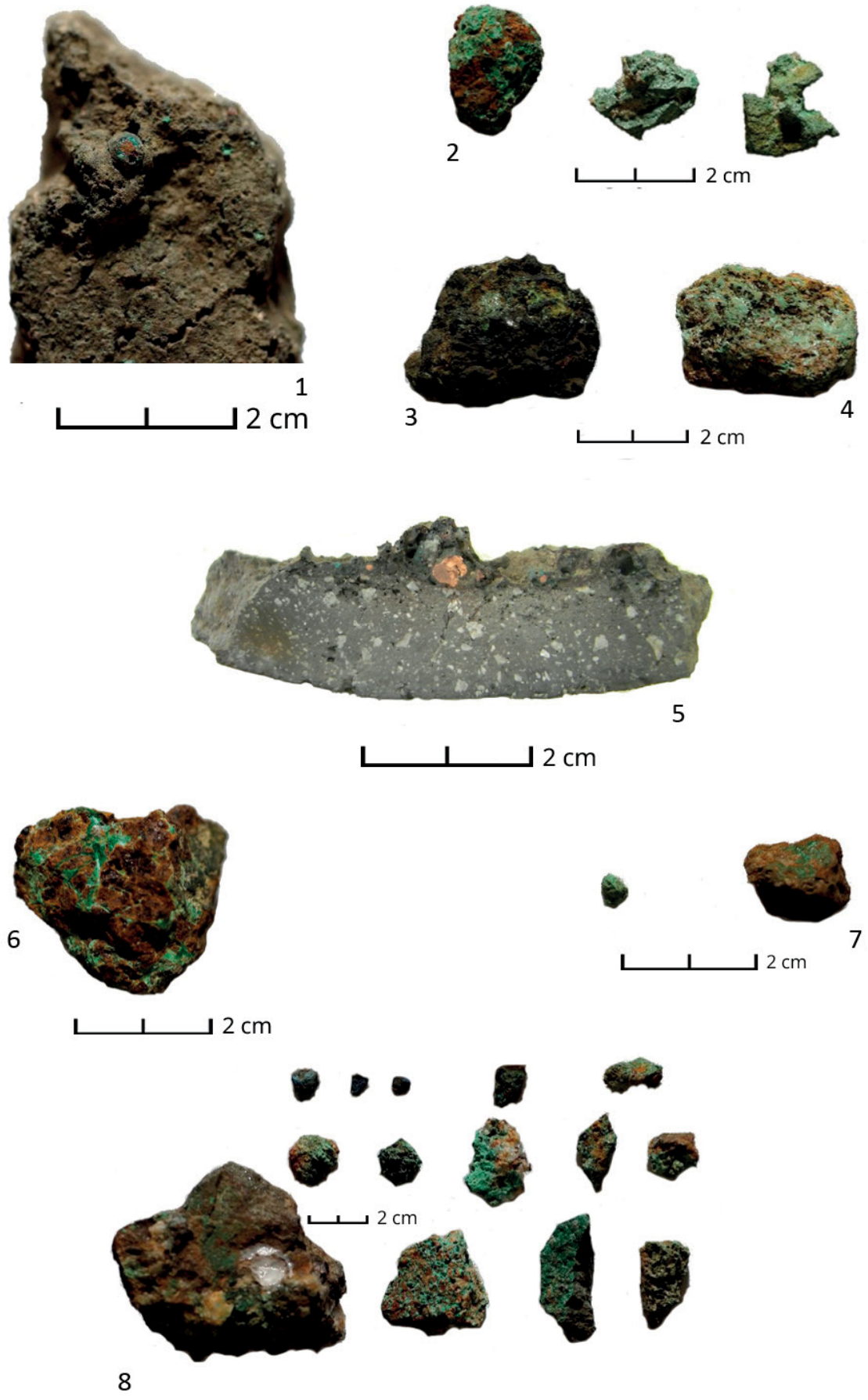


Fig. 3. Photographs of some analysed samples with ID numbers (see *table 1*).



Fig. 4. Photographs of some analysed samples with ID numbers (see *table 1*).



Fig. 5. Subarea of the multi-level settlement of Akladi Cheiri during excavations in 2009 (left) and pit 28 (right).

trench was therefore not performed since the major aim of this part of the field study was the collection of ore samples and a survey of possible smelting sites.

It was above all the modern mining activity that extended until 1990 (Presiyanov/Dimitrov 1998) which largely destroyed older structures. Accordingly, it was challenging to obtain sample material from locations with signs of pre-modern extraction.[8] However, secondary copper minerals are still scattered over the surface around the modern mining installations and could be collected. For prehistoric miners, it seems to have been relatively easy to exploit the conspicuously-coloured copper ores from the weathering zones, so that it is likely that not only one deposit or extraction area was used, but rather many small, frequently exploited ore mineralisations exposed on the surface.

Methodology

The pioneers of trace element analysis of archaeological metal objects, Otto and Witter (1952, 38 f.), believed that two ore deposits would never be identical in their mineral composition and that, therefore, would not produce copper that is identical in its chemical composition, especially in its trace element pattern. Accordingly, it should theoretically be possible that all copper artefacts could be related to specific ore deposits. It soon turned out that this view was much too simplistic, mainly because of the large variability of ore deposits at the micro- and the macro-scale leading to the substantial overlap of trace element concentrations. Indeed, the authors of the largest analytical program of European Bronze Age metal objects that followed along these lines – the SAM project (Studien zu den Anfängen der Metallurgie, Junghans et al. 1960; 1968; 1974) – specifically excluded the aim to identify the geological sources of prehistoric copper, because, in their view, the identification of the geological source of the metal would not be possible due to the large number of analyses required to characterise all known copper deposits and smaller occurrences in Europe. Instead, since it was thought that the complexities induced by the smelting of ores and (re)melting of metals would make it difficult anyway to relate metal objects to specific ore sources, the project sought to identify compositional groupings of metal objects to study their distribution in space and time.

A breakthrough came mainly with the introduction of lead isotope analysis, first applied to lead (Brill/Wampler 1965; Grögler et al. 1966) and silver (Gale et al. 1980), and later extended to copper and copper-based alloys (Gale/Stos-Gale 1982; Pernicka et al. 1984). In addition, new analytical techniques became available that were more sensitive and more precise than the previously

8 At the sites of Varli Bryag, Zidarovo and Propadnala Voda the sampling took place at the historical/modern mining trenches.

prevailing optical emission spectrometry and the combination of geochemical and metallurgical knowledge lead to a better understanding of the behaviour of trace elements during smelting (Pernicka 1999). The combination of these two methodological approaches has resulted in several examples of successful provenance studies where the geological sources of prehistoric copper objects could convincingly be identified (e.g. Stos-Gale et al. 1997; Pernicka et al. 1997).

Lead Isotope Ratios

For lead isotope analysis, the samples were decomposed with mineral acids and from the resulting solution, lead was separated following the procedure by Niederschlag et al. (2003). As it has frequently been demonstrated (e.g. Cui/Wu 2011 with references), it can safely be assumed that the isotope composition of lead remains unchanged during ore processing and smelting and therefore ensures direct comparability of ores and artefacts derived thereof (Pernicka 1987), as long as the unsmelted copper ore originates from a single deposit and was not blended with copper ore from multiple deposits, so no addition of lead occurred from another deposit and during recycling (Begemann/Schmitt-Strecker 2008). The results are summarised in table 2.

It is an important requirement for the application of lead isotope ratios for provenance studies that the variation within a certain deposit is smaller than the variation between all deposits considered. This is often fulfilled because the formation of a metal ore deposit involves not only the concentration of a metallic element but also the separation from uranium and thorium so that no further measurable changes of the lead isotope composition occurs within the deposit during its geological lifetime. This is actually the basis for the success of the method as many deposits exhibit relatively small variations in the order of a few per mille while the overall range of lead isotope ratios is much larger. Unfortunately, this requirement is not always fulfilled, especially with copper deposits with very low lead concentrations. In such cases, the lead isotope ratios in the ore can be altered by lead that may have been remobilised from the host rock. Sometimes copper ores are even associated with uranium, which results in highly variable lead isotope ratios even on the microscale. Since uranium (and thorium) continue to decay within the deposit, they continually produce ^{206}Pb, ^{207}Pb, and ^{208}Pb, but not ^{204}Pb. This is somewhat misleadingly called 'radiogenic' lead, meaning that the lead isotope ratios cannot be used to calculate a geological age of formation of the deposit where one assumes that after formation the deposit is a closed system with respect to lead. The 'radiogenic' lead is mixed with the so-called common lead that was included at the time of formation of the deposit. Since the mixing ratios of radiogenic and common lead depend on the U/Pb ratios (thorium is much less mobile and rarely found in copper deposits), which can vary on the microscale resulting in a wide range of correlated lead isotope ratios in samples from the same deposit. An example of such a complication for provenance studies are the copper deposits of the Medni Rid region. Unfortunately, this situation is not confined to the copper ores of the Medni Rid region only. There are other deposits in the Old World that show a similar spread of lead isotope ratios, for example, Rudna Glava in Serbia (Pernicka et al. 1993), Timna and Feinan in Israel and Jordan (Hauptmann et al. 1992; Hauptmann 2007), Sardinia (Boni/Köppel 1985), the Erzgebirge (Niederschlag et al. 2003), the Mitterberg region in the eastern Alps (Pernicka et al. 2016) and presumably many others.

In exploratory test samples, relatively high concentrations of uranium were indeed found in the ore samples, at least in the samples from Propadnala Voda, Medni Rid Mt. and the Rosen Ore Field.[9] This generally suggests high U/Pb ratios in these deposits (compare Presiyanov/Dimitrov 1998), which, again, explains the large range of values in some of the examined samples. Although the presence of radiogenic lead, complicates the ability to identify the possible source(s) of a single copper artefact, the slope of the correlation trend may be different in different regions so that a

9 Our own investigations confirm that the ore from Propadnala Voda is characterised by elevated radiation levels of 0.5 µS/h to 0.8 µS/h, compared with 0.15 µS/h in Varli Bryag.

Lab No.	ID	Material	Site	Context	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
Medni Rid Region									
MA- 135454	9	Malachite	Rosen Ore Field	Mineralisation	1.8253	0.74540	21.095	15.724	38.505
MA- 141990	14	Malachite	Rosen Ore Field	Mineralisation	1.8196	0.73895	21.320	15.754	38.795
MA- 145532	21	Malachite	Rosen Ore Field	Mineralisation	1.8180	0.74178	21.213	15.735	38.564
MA- 141989	13	Malachite	Propadnala Voda	Mineralisation	1.7136	0.68114	23.390	15.932	40.080
MA- 145533	22	Malachite	Propadnala Voda	Mineralisation	1.8215	0.74430	21.144	15.737	38.513
MA- 145534	23	Slag	Propadnala Voda	Surface find	1.5612	0.64458	24.683	15.910	38.535
MA- 147718	28	Malachite	Propadnala Voda	Mineralisation	1.1363	0.48083	34.017	16.356	38.654
MA- 152442	54	Malachite	Propadnala Voda	Mineralisation	1.6644	0.68392	23.147	15.830	38.525
MA- 147715	24	Malachite	Propadnala Voda	Mineralisation	1.8286	0.74644	21.090	15.743	38.566
MA- 147716	25	Malachite	Propadnala Voda	Mineralisation	2.0422	0.82842	18.872	15.634	38.540
MA- 147722	37	Malachite	Propadnala Voda	Mineralisation	1.9733	0.80186	19.536	15.666	38.551
MA- 147719	29	Malachite	Kyumyurluka (mine)	Mineralisation	1.3509	0.56261	28.603	16.092	38.639
MA- 147721	30	Malachite	Kyumyurlake (smelting)	Mineralisation	1.7921	0.72624	21.750	15.795	38.978
MA- 147723	53	Malachite	Surne-shko Kladenche	Mineralisation	2.0298	0.82333	18.996	15.640	38.558
MA- 147717	26	Malachite	Medni Rid Mt.	Mineralisation	1.0880	0.46356	35.428	16.423	38.546
Regional copper mineralisations									
MA- 135453	8	Malachite	Varli Brjag	Mineralisation	2.0637	0.83611	18.695	15.631	38.581
MA- 141988	12	Malachite/ azurite	Varli Brjag	Mineralisation	2.0638	0.83396	18.766	15.650	38.730
MA- 135455	10	Malachite	Atiya	Mineralisation	2.0394	0.82900	18.886	15.657	38.517
MA- 141987	11	Malachite	Zidarovo	Mineralisation	2.0656	0.83593	18.717	15.646	38.662
MA- 141992	19	Malachite	Zelenata Kanara	Mineralisation	2.0613	0.81434	19.305	15.721	39.793
MA- 141992	19	Malachite	Zelenata Kanara	Mineralisation	2.0613	0.81434	19.305	15.721	39.793
MA- 141991	15	Malachite	Aibunar	Mineralisation	2.0819	0.84380	18.512	15.621	38.541

Lab No.	ID	Material	Site	Context	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
Archaeological samples									
MA- 133042	62	Malachite	Akladi Cheiri	Settlement	1.8394	0.75056	20.959	15.731	38.552
MA- 133043	63	Malachite	Akladi Cheiri	Settlement	1.4452	0.59936	26.726	16.018	38.624
MA- 133044	54	Malachite	Akladi Cheiri	Settlement	2.0196	0.81944	19.096	15.648	38.566
MA- 133045	65	Malachite	Akladi Cheiri	Settlement	2.0541	0.83240	18.794	15.644	38.605
MA- 133046	66	Limonite/ malachite	Akladi Cheiri	Settlement	1.9520	0.79405	19.731	15.667	38.515
MA- 133047	67	Limonite/ malachite	Akladi Cheiri	Settlement	2.0372	0.82633	18.925	15.638	38.554
MA- 133048	68	Crucible/slag	Akladi Cheiri	Settlement	2.0560	0.83383	18.730	15.618	38.509
MA- 133049	69	Crucible/cera- mic	Akladi Cheiri	Settlement	2.0586	0.82916	18.890	15.663	38.887
MA- 133050	70	Copper	Akladi Cheiri?	Settlement	1.6225	0.66786	23.761	15.869	38.552
MA- 135447	1	Furnace wall	Akladi Cheiri	Settlement	2.0487	0.82598	18.947	15.650	38.817
MA- 135448	2	Malachite	Akladi Cheiri	Settlement	0.9262	0.40165	41.616	16.715	38.546
MA- 135449	3	Malachite	Akladi Cheiri	Settlement	2.0075	0.81549	19.171	15.634	38.486
MA- 135450	4	Malachite	Akladi Cheiri	Settlement	1.9927	0.80684	19.396	15.650	38.651
MA- 135451	6	Malachite	Budzhaka	Settlement	2.0457	0.83001	18.822	15.622	38.505
MA- 135452	7	Malachite	Alepu	Settlement	2.0137	0.81748	19.123	15.633	38.508
MA- 152458	55	Malachite	Hadzhi-dimitrovo	Settlement	1.9778	0.79940	19.621	15.685	38.806
MA- 152459	56	Malachite	Hadzhi-dimitrovo	Settlement	2.0640	0.83408	18.759	15.647	38.718
MA- 152460	57	Malachite	Dana Bunar 2	Settlement	2.0611	0.83394	18.775	15.657	38.697

Table 2. Composition of lead isotope ratios of the analysed copper ore samples.

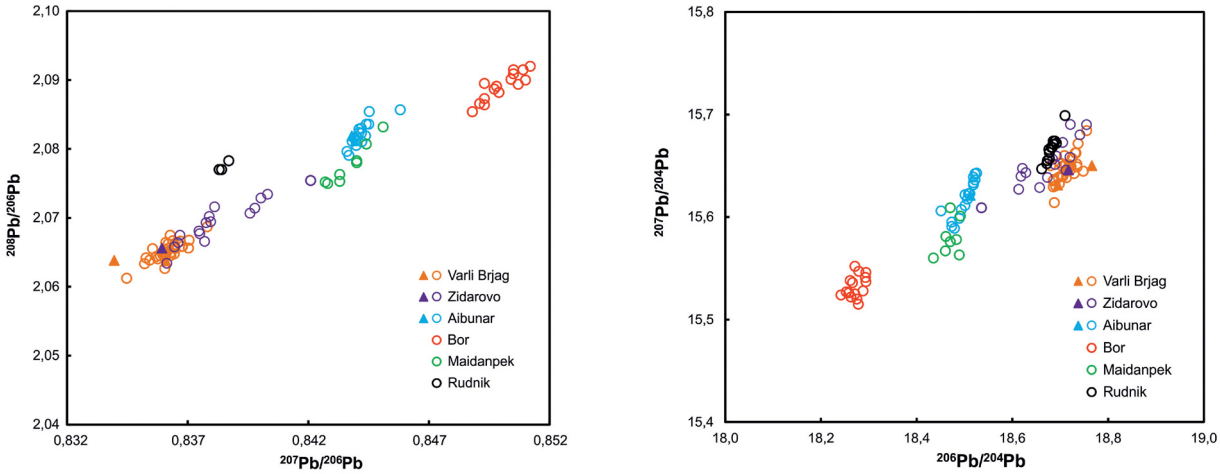


Fig. 6. Lead isotope ratios of the analysed copper ore samples (solid triangles), as well as data, are taken from the literature (open circles) from selected deposits in Bulgaria (Varli Bryag, Zidarovo, Ai Bunar) and Serbia (Bor, Maidanpek, Rudnik). Literature data from Pernicka et al. 1993; 1997; Dimitrov 2002; Gale et al. 1991; Stos-Gale et al. 1998.

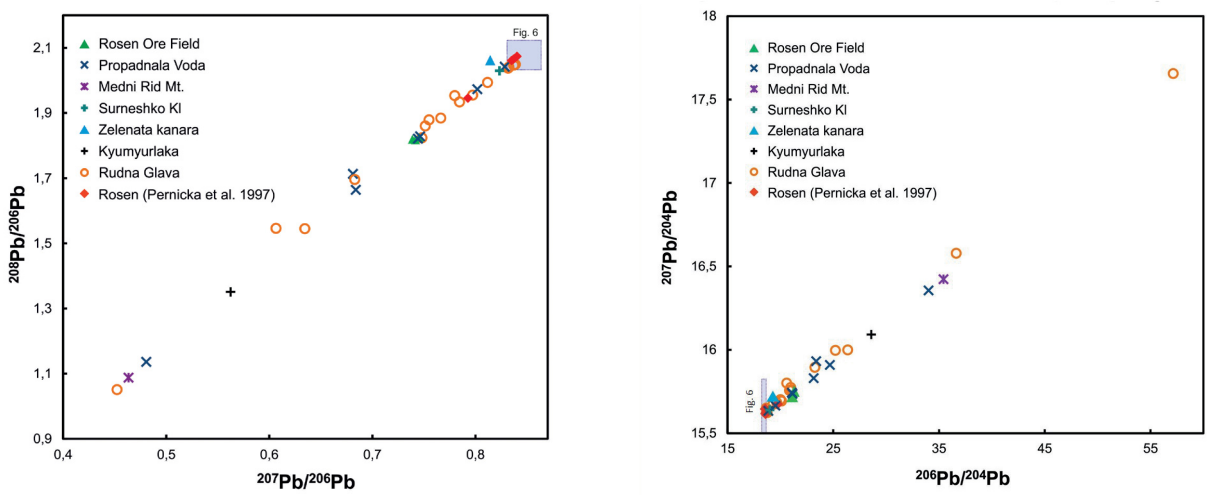


Fig. 7. Diagram of the $^{207}Pb/^{206}Pb$ isotope ratios compared with the $^{208}Pb/^{206}Pb$ ratios (left) and $^{207}Pb/^{206}Pb$ compared with $^{206}Pb/^{204}Pb$ (right) of the copper ores from Medni Rid. The lead isotope ratios are clearly different from other ore districts outside Medni Rid (indicated by the blue rectangle, which outlines the diagrams in fig. 6).

suite of copper objects that are supposed to derive from one region may, within limits, still be related to it by their lead isotope ratios. The abundance ratios of $^{207}Pb/^{206}Pb$ vs. $^{208}Pb/^{206}Pb$ and $^{206}Pb/^{204}Pb$ vs. $^{207}Pb/^{206}Pb$ can be used to identify characteristic isotope patterns of the ore deposits. In fig. 6 are plotted the $^{207}Pb/^{206}Pb$ vs. $^{208}Pb/^{206}Pb$ ratios of the deposits Varli Bryag and Zidarovo, which are located in the vicinity of Medni Rid together with those from Ai Bunar in central Bulgaria and the Serbian deposits of Bor, Maidanpek and Rudnik that were exploited during the Copper Age. Isotopically rather similar signatures of lead within each deposit combined with larger differences between deposits allow for a clear differentiation. First of all, it may be noted that the analyses of this study show very good agreement with the data from the literature so that the pooling of the data is possible. Only Varli Bryag and Zidarovo overlap in both diagrams, which most likely reflects their geographical vicinity and, potentially, their genetic relationship.

The investigated individual deposits in the Medni Rid area exhibit a decisively different picture. Large variations in abundance ratios (ranges) in principle provide a clear differentiation

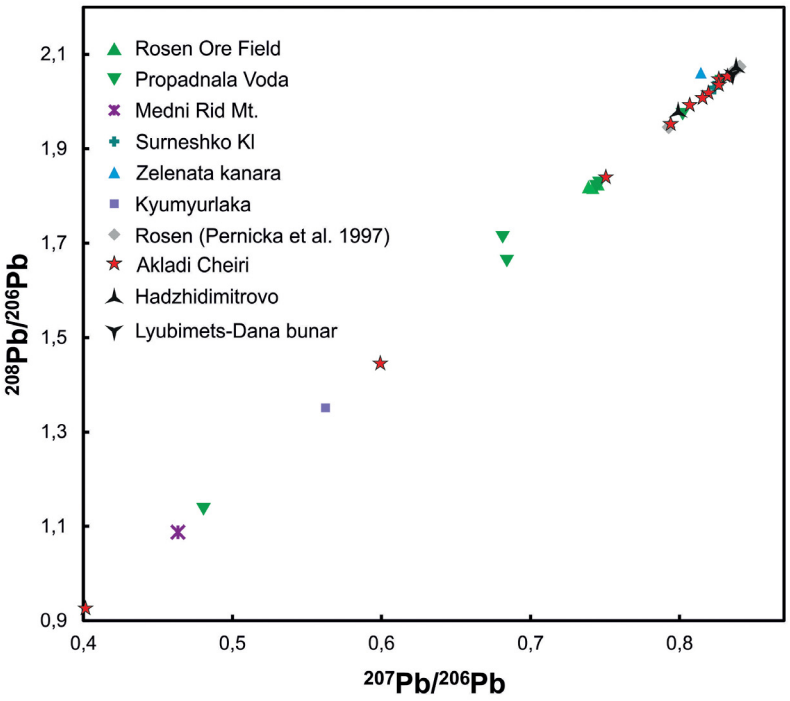


Fig. 8. Comparison of the lead isotope ratios of the Medni Rid samples of copper ore, copper slag and crucibles from the chalcolithic settlement at Akladi Cheiri. In addition, one sample of copper ore each from the Late Neolithic/Copper Age settlements Alepu and Budzhaka were also analysed and plot in the region of $^{208}Pb/^{206}Pb \approx 2.0$, similar as most of the samples from Akladi Cheiri.

between regional and supraregional deposits and thereby also corroborate earlier investigations by Pernicka et al. (1997) and Dimitrov (2002) who identified such highly radiogenic lead in chalcolithic copper artefacts and suggested that they may derive from the Medni Rid area (*fig. 7*). Of course, the question arises, whether a radiogenic lead is unique for the Medni Rid region. Unfortunately, this is not the case as mentioned above, but it is also not too frequent. In southeastern Europe, at present, there is only one copper deposit – Rudna Glava – known with highly radiogenic lead, which is also shown in fig. 7. It is obvious, that these two deposits cannot be distinguished by their lead isotope ratios even when a suite of samples is available, because of the slope of the trend in fig. 7 (left) that depends on the U/Th ratio in the source rocks of the deposit is very similar.

Nevertheless, it seems to be possible to differentiate between smaller areas within the Medni Rid region (*fig. 8*), but the number of samples of each individual mineralisation is too small to consider them fully characterised. While Propadnala Voda, Medni Rid Mt., and possibly the locality of Kyumyurlaka (from where only one sample was available) show large variations of their lead isotope ratios, Surneshko Kladenche, Zelenata Kanara (Silistar), and Rosen ore field have less radiogenic lead and, accordingly, much less variability. This may suggest that not all copper mineralisations in the Medni Rid region were impregnated with uranium. On the other hand, a few ore samples that were picked up at the surface at one locality could well derive from the same ore vein.

There seems to be a problem with our locality Rosen orefield. Other samples designated as ‘Rosen’, ‘Rosen Centr.’, and ‘Rosen-s.klad’ were already analysed by Pernicka et al. (1997, tab. A5) but do not agree with the three samples from this study. The term ‘Rosen’ used by Pernicka et al. (1997) was used in a more general way and may actually refer to sites located nearby (for instance the deposit Surneshko Kladenche described here) but not to the actual district of Rosen, that is the term ‘Rosen ore field’ in our study.

As yet is was not possible to identify remains of chalcolithic mining in the field in the Medni Rid region (see Kunze et al. 2018 and Kunze et al., this volume, 307–326) so that it is important to relate finds of copper ore and smelting products to these deposits. To this purpose, samples of copper ore, copper slag, and crucibles from the Late Neolithic/Copper Age settlements of Akladi Cheiri and of Alepu and Budzhaka at the coast of the Black Sea were analysed and compared with the ore samples from the Medni Rid region. The result

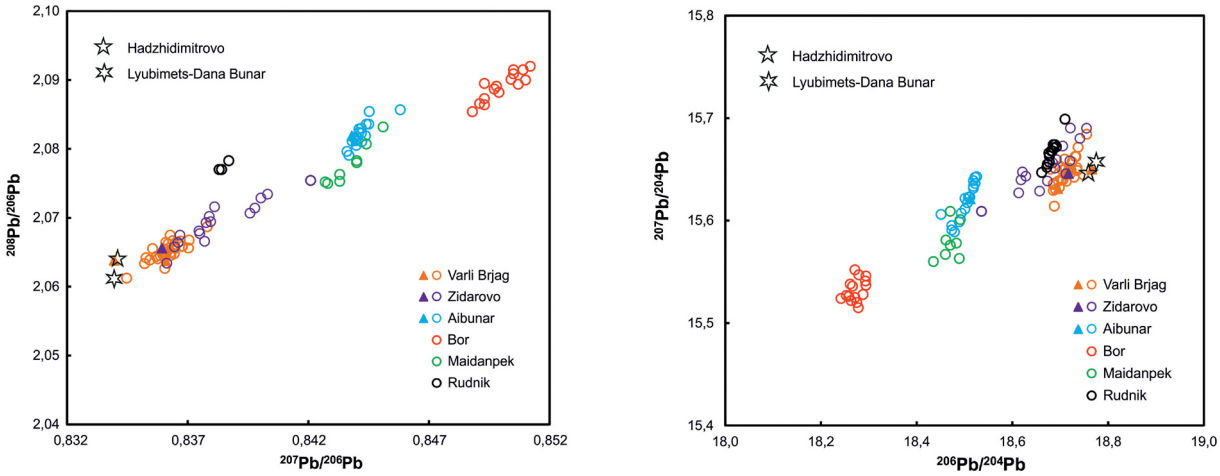


Fig. 9. Lead isotope ratios of the analysed copper ore samples (solid triangles) as well as data taken from the literature (open circles, for references, see *fig. 6*) from selected deposits in Bulgaria (Varli Bryag, Zidarovo, Ai Bunar) and Serbia (Bor, Maidanpek, Rudnik) compared with two Late Neolithic copper ore samples from southeastern Bulgaria.

is shown in fig. 8. It is very obvious that along the Black Sea shore only the Medni Rid region provides a good match for the samples from the archaeological sites, while the nearby deposits of Zidarovo and Varli Bryag can be excluded as possible ore sources although both were certainly exploited in antiquity but apparently not in the Chalcolithic. The most prominent chalcolithic copper mine of Ai Bunar can also be excluded but not Rudna Glava. However, the geographical proximity clearly speaks for a relation between Medni Rid and the chalcolithic settlements of the same area. The outreach of Medni Rid was much larger as indicated by at least one sample from the Late Neolithic site of Hadzhidimitrovo close to Yambol that also has radiogenic lead (*fig. 8*).

Incidentally, as it was suggested that the copper minerals found at Hadzhidimitrovo could derive from the large porphyry copper deposit of Prohorovo, it may be worthwhile to discuss the possible ore source(s) of the Late Neolithic samples from Hadzhidimitrovo and Dana Bunar 2. Since the lead isotope ratios of Prochorovo resemble those of the copper ores from Ai Bunar (Amov 1999), this deposit can safely be excluded as a possible source (*fig. 9*). However, Varli Bryag provides a perfect match, especially with the sample taken during this study. The agreement is less good for the samples published by Stos-Gale et al. (1998). However, they were obtained from modern mining while our sample was taken from the exposed ancient mining traces on the surface.

Chemical Composition

The major and trace element concentrations as determined by neutron activation analysis are summarised in table 3. It is often maintained that chemical analyses alone will not allow copper-alloy artefacts to be matched to their parent copper ores. Although this is partly correct, there are cases where the trace element pattern may be more indicative of an ore source than lead isotope ratios. At Feinan, Jordan, for example, the ore deposit is chemically homogeneous but shows wide variations in its lead isotope ratios (Hauptmann et al. 1992) like in the Medni Rid area. In such a situation, it is common sense that a combination of both sets of data – lead isotope ratios and trace element concentrations – will provide better discrimination between different sources. Geochemical and metallurgical considerations have resulted in a relatively small number of elements that are useful for provenance discussions, namely as Ag, As, Co, Ni, Sb, Bi, Se, Te and Au (Pernicka 1999), especially when it can be assumed that mostly oxidic ores were used. Their reduction to copper metal is quite straightforward compared with the processing of sulphide ores, which cannot be reduced directly

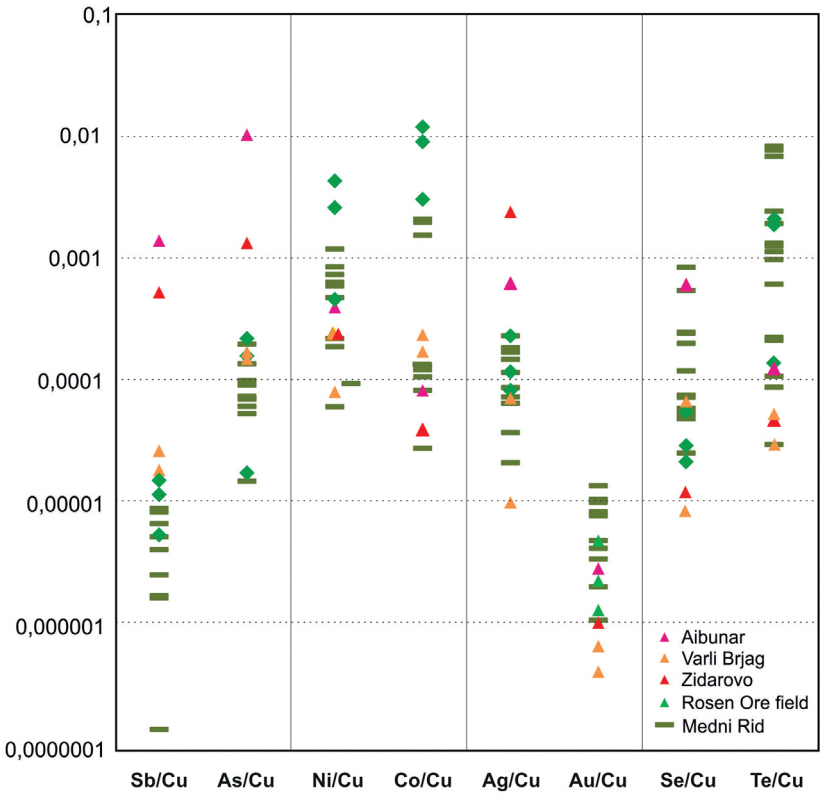


Fig. 10. Comparison of the relative trace element contents (normalised to copper) of the copper ore samples from the Medni Rid area and its neighbouring deposits (Ai Bunar, Zidarovo, Varli Bryag). The Rosen orefield is indicated by separate symbols from the other Medni Rid sites to test whether the locations within the Medni Rid area can be differentiated, which is, however, not possible.

but must be oxidised (roasted) before reduction. This is usually accomplished at around 700°C, well below the melting point of copper and most ore minerals. Nevertheless, it has been suggested that volatile elements such as zinc, arsenic antimony and, presumably, selenium and tellurium, are partly lost during roasting (Tylecote et al. 1977).

Since the absolute concentrations of trace elements in ore samples are of limited value for geochemical characterisation, the following discussion is based on ratios of trace element versus copper concentrations in order to ensure comparability. Furthermore, one must bear in mind that for chalcolithic copper production only very rich ores would have been useful. Therefore, only ore samples with more than 10% copper were considered in this discussion with the exception of two ore samples from Rosen orefield with roughly 4 and 2.5% copper. The trace element patterns in fig. 10 show that it is not possible to differentiate between the various sample locations within the Medni Rid area but that it seems to be possible to distinguish Ai Bunar and Zidarovo from Medni Rid by their higher concentrations of arsenic, antimony and silver, which corroborates the differences between those three deposits in their lead isotope ratios. In addition, it seems that Zidarovo and Varli Bryag, which largely overlap in their lead isotope ratios differ in their contents of the same elements. However, this would have to be substantiated by the analysis of more ore samples. There is furthermore an indication that the ore samples from the Rosen ore field tend to contain more nickel and cobalt than the other samples from the Medni Rid area, but again this would have to be checked with more samples. Incidentally, there is one other copper deposit known in the wider surrounding of Medni Rid, namely Catak Tepe near Dereköy south of the Strandzha mountains along the border of present-day Bulgaria and Turkey. The site was intensively worked, presumably in prehistory but also in the Middle Ages. A large slag pile is estimated to contain ca. 100,000 metric tons of copper slag. Thermoluminescence and radiocarbon dates from this slag pile yielded ages between 30 BC and 630 AD. Of special interest is the fact that a single sample of copper ore from this location contained highly radiogenic lead, similar to Medni Rid (Wagner et al. 1986). However, three ore samples that were analysed by neutron activation also

Lab no.	No.	Material	Site	Context	Cu [%]	Fe [%]	As	Sb	Co	Ni	Ag	Au	Zn	Sn	Se	Te
Medni Rid Region																
MA-135454	9	Malachite	Rosen Ore Field	Mineralisation	14.2	5.4	2.6	0.81	438	70	12.2	0.731	167	< 250	7.2	33
MA-141990	14	Malachite	Rosen Ore Field	Mineralisation	3.78	17	6.2	< 0.6	344	100	4.6	0.053	173	< 93	< 1	74
MA-145532	21	Malachite	Rosen Ore Field	Mineralisation	2.55	19	5.8	0.31	305	111	6.1	0.062	167	34	< 2	63
MA-141989	13	Malachite	Propadnala Voda	Mineralisation	28.6	0.55	18.2	2.6	31.7	65	26	1.27	65	78	17.6	283
MA-145533	22	Malachite	Propadnala Voda	Mineralisation	19.8	0.5	20.4	0.85	25.1	97	15	0.721	115	< 160	11.0	229
MA-147718	28	Malachite	Propadnala Voda	Mineralisation	13.1	3.3	9.7	0.23	279	160	2.9	1.88	68	48	10.1	166
MA-152442	54	Malachite	Propadnala Voda	Mineralisation	18.5	< 0.4	17.5	0.5	22.5	121	7.2	2.06	77	< 140	14	248
MA-147715	24	Malachite	Propadnala Voda	Mineralisation	44.2	0.7	6.9	0.066	12.8	28	106	3.63	50	31	26.8	49
MA-147716	25	Malachite	Propadnala Voda	Mineralisation	14.6	4.1	8.1	< 0.4	307	< 110	22.5	0.169	184	< 110	126	13.1
MA-147722	37	Malachite	Propadnala Voda	Mineralisation	45.5	1.68	64.5	0.83	63.0	< 89	80	0.983	85	43	56.3	102
MA-147719	29	Malachite	Kyumyurluka (mine)	Mineralisation	13.3	20.0	9.7	0.91	267	81	9.0	0.682	194	< 190	7.3	83
MA-147721	30	Slag	Kyumyurlaka (smelting)	Mineralisation	0.8	23	1.7	< 0.6	96	70	< 3	<0.02	83	< 220	4,3	63
MA-147723	53	Malachite	Surneshko Kladenche	Mineralisation	38.8	1.01	79.4	3.4	33.3	38	74	3.42	39	< 29	97.2	12.1
MA-147717	26	Malachite	Medni Rid mountain	Mineralisation	14.8	25.0	10.8	0.82	233	130	17.8	1.56	127	< 72	30.8	1010

Lab no.	No.	Material	Site	Context	Cu [%]	Fe [%]	As	Sb	Co	Ni	Ag	Au	Zn	Sn	Se	Te
Regional copper mineralisations																
MA-135453	8	Malachite	Varli Bryag	Mineralisation	27.6	1.06	48.7	7.67	49.0	23	2.9	0.196	405	< 100	19.4	< 7
MA-141988	12	Malachite/azurite	Varli Bryag	Mineralisation	22.1	2.50	34.1	4.27	54.0	< 110	16.4	0.097	401	< 150	< 2	< 12
MA-141987	11	Malachite	Zidarovo	Mineralisation	16.3	5.2	222	88.4	6.7	< 81	398	0.179	212	< 150	< 2	8
MA-141991	15	Malachite	Aibunar	Mineralisation	10.03	5.8	1040	143	8.6	41	64	0.305	9400	< 210	62.4	13
Archaeological samples																
MA-133042	62	Malachite	Akladi Cheiri	Settlement	50	1.42	1	< 0.5	570	< 140	42	5.4	120	< 130	8,6	7
MA-133043	63	Malachite	Akladi Cheiri	Settlement	51	18	34	1.2	43	< 170	77	0.15	170	< 170	160	28
MA-133044	64	Malachite	Akladi Cheiri	Settlement	23	12	63	1.5	11	< 100	13	1.5	46	19	17	28
MA-133045	65	Malachite	Akladi Cheiri	Settlement	48	0.35	2.8	0.83	11	15	61	0.05	110	< 60	24	14
MA-133046	66	Limonite/malachite	Akladi Cheiri	Settlement	3	29	150	0.62	9400	< 490	14	0.84	1100	< 510	35	82
MA-133047	67	Limonite/malachite	Akladi Cheiri	Settlement	36	4.8	6	0.43	3800	< 320	40	5.2	570	< 330	51	40
MA-135449	3	Malachite	Akladi Cheiri	Settlement	8.38	44	7.28	0.63	670	50	4,8	3.21	102	104	4	12
MA-135450	4	Malachite	Akladi Cheiri	Settlement	17.4	5	3.8	0.33	32.2	67	< 3	0.025	80	140	2.5	16
MA-151990	5	Copper prill	Akladi Cheiri	Settlement	87.1	0.2	39.0	2.30	13.5	30	61	2.47	13	< 200	17.5	11
MA-152458	55	Malachite	Hadzhidimitrovo	Settlement	46.6	< 0.7	2.86	0.31	41	25	607	7.24	752	670	124	72
MA-152459	56	Malachite	Hadzhidimitrovo	Settlement	52.3	< 0.1	58.9	0.46	138	70	< 0.8	0.056	329	< 180	1.5	47

Table. 3. Major and trace element concentrations of copper ore samples accomplished by neutron activation.

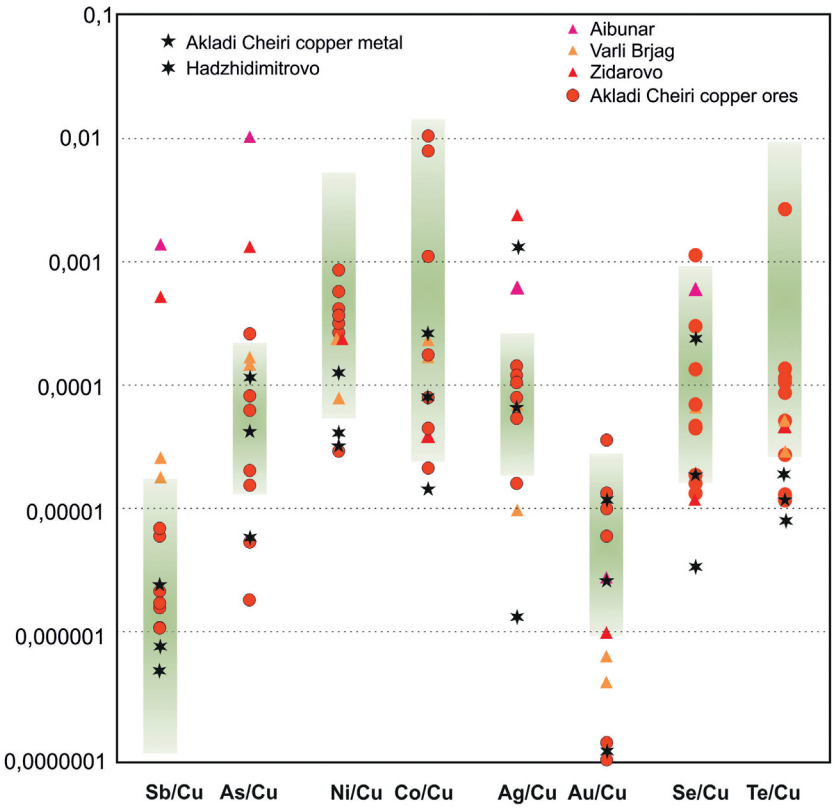


Fig. 11. Comparison of the ranges of trace element contents (normalised to copper) in the ore samples from mineralisations in the Medni Rid area (green columns) and copper ore samples and one copper sample from the chalcolithic settlement of Akladi Cheiri.

contained more arsenic and antimony than the copper ores from Medni Rid, similar to Ai Bunar and Zidarovo.

Of major interest is the comparison of archaeological samples to see, whether they are also consistent in their compositions with Medni Rid like the lead isotope ratios. In fig. 11 the trace element patterns of ore samples from Akladi Cheiri are compared with the concentration ranges of elements which are indicative for provenance in copper ore samples from Medni Rid. There is almost a complete overlap with the exception of three samples from Akladi Cheiri that contain significantly less gold. However, gold is notoriously inhomogeneously distributed in minerals, and the number of ore samples is certainly too small for complete coverage. It is also noteworthy that the copper sample presumably from Akladi Cheiri conforms to this trace element pattern, indicating that it indeed consists of smelted copper. The distinction between native (naturally occurring) and smelted copper is important in the context of Akladi Cheiri, because the site dates from the Late Neolithic in the second half of the 6th mill. BC to the Late Chalcolithic in the second half of the 5th mill. BC and is thus roughly contemporary with the earliest evidence for copper smelting at Belovode in eastern Serbia (Radivojević et al. 2010). Based on analyses of both objects and (native) copper from Anatolia and the Balkans (Pernicka et al. 1993; 1997) it was suggested that very low trace element concentrations (particularly of cobalt and antimony) in copper metal indicate the use of native copper metal, which is also in line with geochemical considerations (Pernicka 1990).

The copper sample from a Late Neolithic context at Akladi Cheiri (ACH 137) is not only consistent in its trace element pattern with copper ores from the Medni Rid area but also contains more cobalt than is usually found in native copper so that it may be concluded that it consists of smelted copper. Thus, it may well even pre-date the finds from Belovode and push the evidence for copper smelting by a few centuries into the late 6th mill. BC.

The combined results of the lead isotope and trace element investigations are indeed a very strong indication that Medni Rid was already known and exploited during the Late Neolithic and Chalcolithic and that copper was produced from its

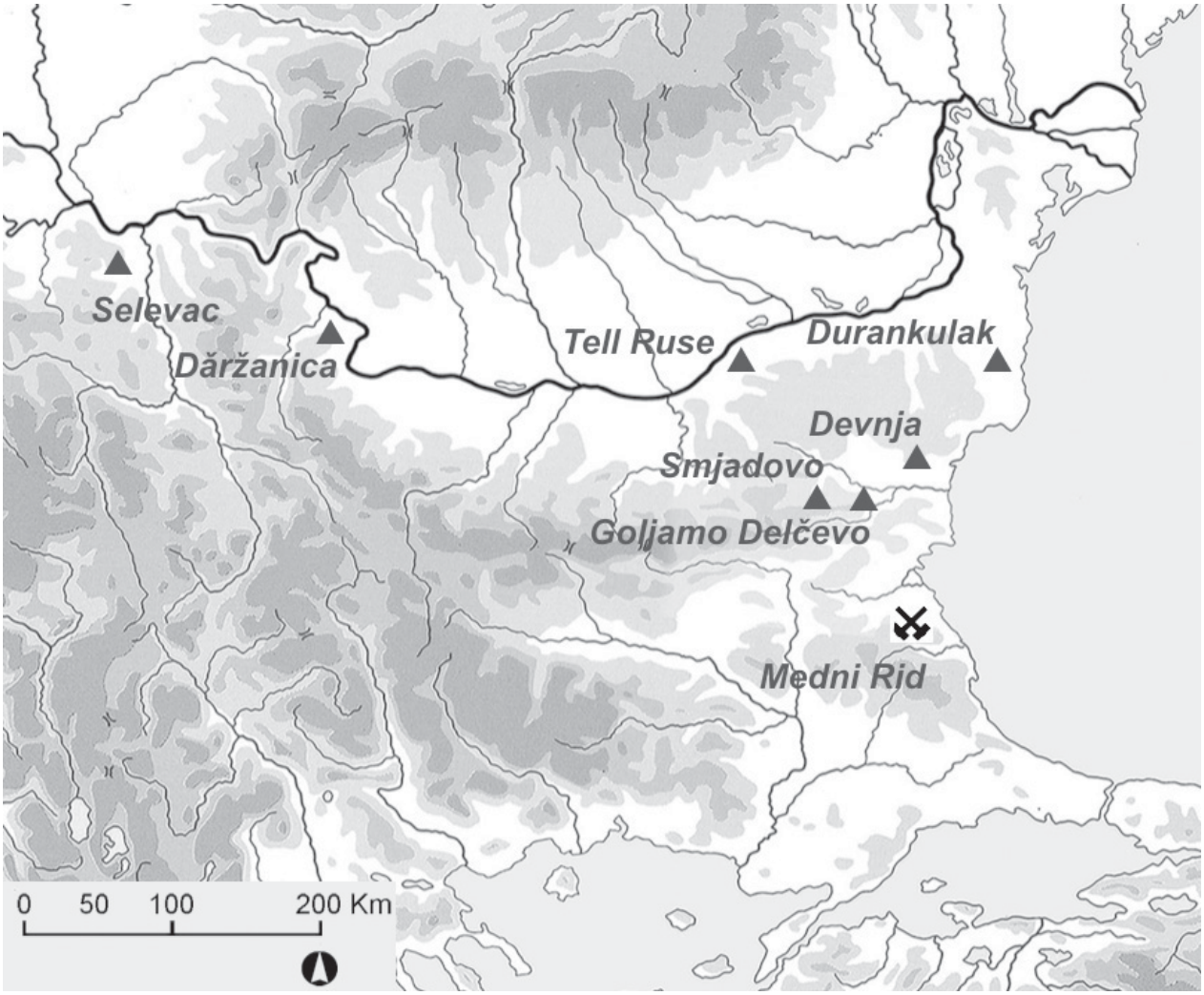


Fig. 12. Late Neolithic and Chalcolithic sites from where copper objects with highly radiogenic lead derive.

ores at Akladi Cheiri (Rehren et al. 2016), although these authors suggest that the smelted ore was rich in sulphides and iron which is not the case with our samples. However, the oxidised zones of copper ore deposits generally contain mixtures of oxide, carbonate, and sulphide minerals intimately intergrown. On smelting, the sulphur would be enriched in the remaining slag. An interesting observation was the presence of high contents of molybdenum in some slag samples. This needs to be checked in ore samples from Medni Rid in the future. However, molybdenum is not expected to appear in copper smelted from such ore, because it is difficult to be reduced to the metal with the processes implied for the Late Chalcolithic (Rehren et al. this volume). Accordingly, it cannot be added to the trace element pattern used to establish a relationship between ores and metal.

Discussion and Conclusion

In the wider context of Late Chalcolithic copper production in south-eastern Europe it was already suggested that, besides Rudna Glava and Ai Bunar, Medni Rid could be identified as a third major source of copper, because altogether 41 Late Neolithic and Chalcolithic copper objects from various sites in Bulgaria and Serbia (*fig. 12*) were found to contain radiogenic lead (Pernicka et al. 1997). So far only two other copper mineralisations with radiogenic lead are known from the Balkans, namely Rudna Glava in eastern Serbia and Dereköy in Turkish Thrace. Rudna Glava is well dated to the Gradac phase or Vinča-Pločnik IIA using Garašanin's (1994/1995) nomenclature. One radiocarbon date of charcoal from Rudna Glava yielded a result of 6220 ± 105 years b.p. (Hd 10820-10789),

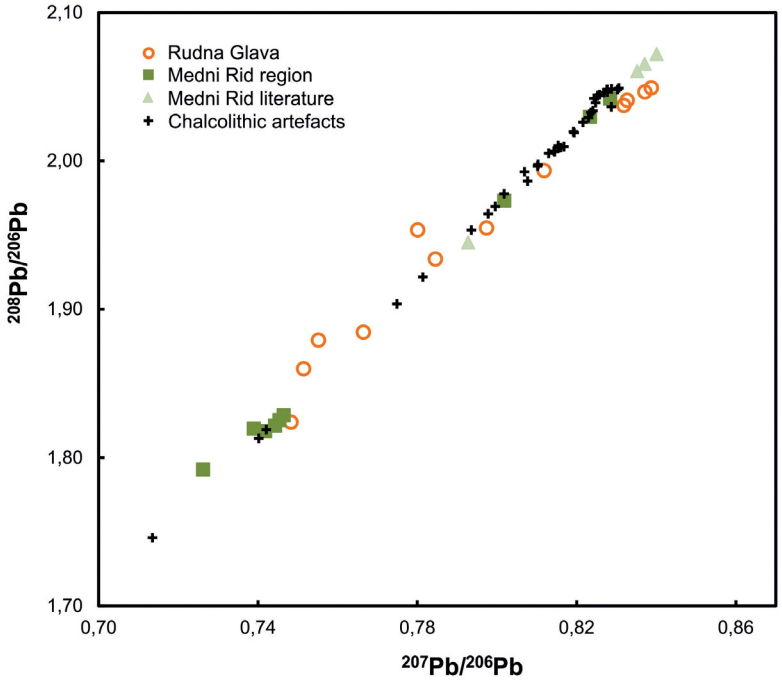


Fig. 13. Comparison of the lead isotope ratios of Late Neolithic and chalcolithic copper artefacts with copper ores from the Medni Rid area (green) and from Rudna Glava in eastern Serbia (orange circles). All artefacts plot precisely along with the trend of the ore samples from Medni Rid.

which corresponds to 5320 to 5060 BC. From a compilation of radiocarbon dates and archaeological considerations, Borić (2009) chronologically identified the Gradac phase as beginning at the turn of the 5th mill. BC and, in the central Serbian Morava valley sites, lasting until about 4600 BC. The mining activities at Dereköy are not well explored, but there is some evidence of prehistoric works (Wagner et al. 1986).

In fig. 13 the lead isotope ratios of those 41 artefacts are compared with copper ores from the Medni Rid region and Rudna Glava. The artefacts plot exactly along the trend line of the ores from Medni Rid while the ores from Rudna Glava show more scatter along the same trend line (*fig. 14*). However, it must be noted that the precision of measurement had improved substantially due to new instrumentation that was not available when the Rudna Glava samples were measured so that a clear differentiation between the two copper sources may not be possible when the $^{208}Pb/^{206}Pb$ ratios are below 2.04.

Here we can again use the trace element pattern (*fig. 15*) that shows that we can distinguish between the two chalcolithic copper sources by systematically lower concentrations of gold, silver, nickel and selenium in ores from Rudna Glava. It shows that the trace element patterns of most copper objects with highly radiogenic lead are consistent with Medni Rid but not with Rudna Glava. This confirms the somewhat surprising statement of Pernicka et al. (1993) that so far no chalcolithic copper object from south-eastern Europe is known that matches the geochemical characteristics of Rudna Glava. This certainly does not diminish the importance of the site as one of the earliest, if not the earliest, mine where copper ores were extracted. But it seems that this ore was not used to produce copper metal. It has been suggested that the relatively small deposit was mainly mined for malachite as a mineral for the production of beads and other ornaments, which are also abundant in the south-east European Chalcolithic.

Most of the copper objects with highly radiogenic lead derive from the Late Neolithic and Chalcolithic cemeteries of Durankulak in north-east Bulgaria. While in the publication of Pernicka et al. (1997) the objects were more or less preliminarily dated as Late Neolithic, Early, Middle and Late Chalcolithic, it is now possible to date these objects and most others more precisely due to the publication of the site by H. Todorova (2002). From the summary of the dates in table 4 it transpires that the copper with highly radiogenic lead is mainly

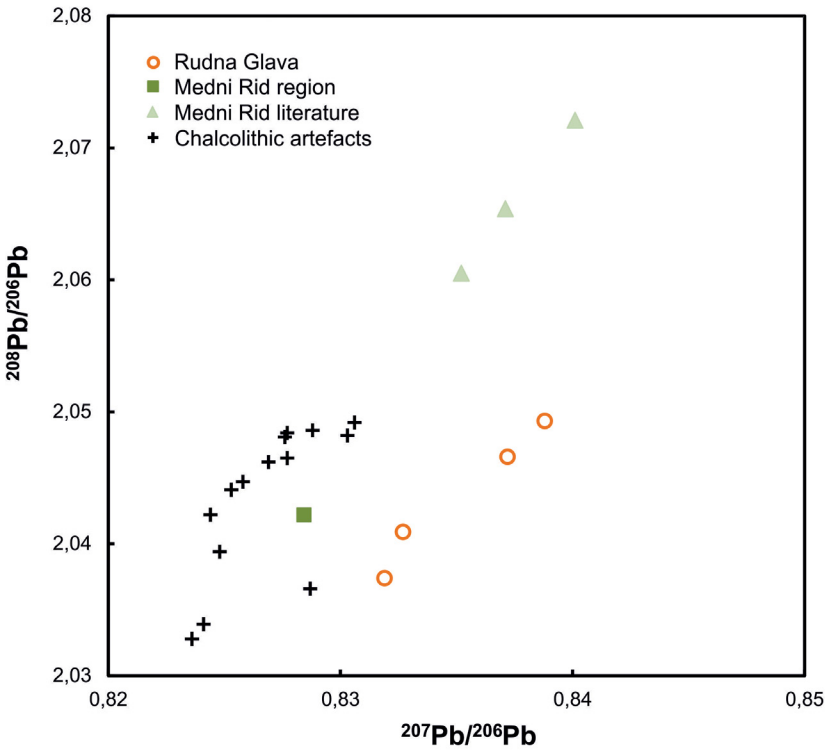


Fig. 14. Detail of fig. 13 shows the difference between Rudna Glava and both Medni Rid and the Late Neolithic and Chalcolithic copper objects above a value of ca. 2.04 for the $^{208}Pb/^{206}Pb$.

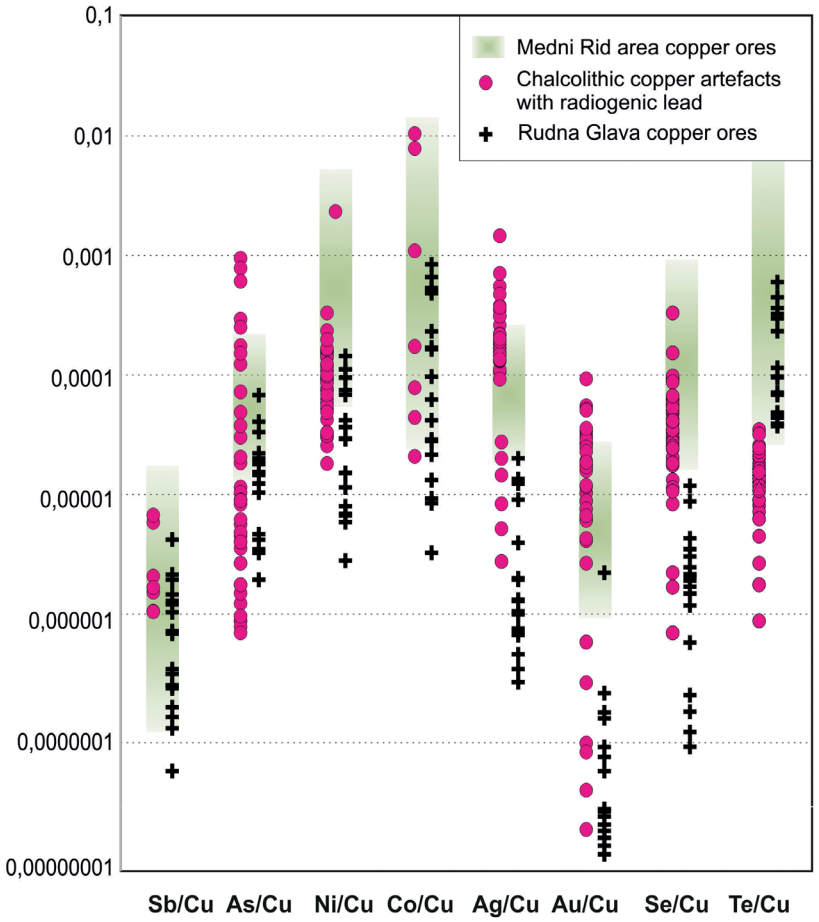


Fig. 15. Comparison of the ranges of trace element contents (normalised to copper) in the ore samples from mineralisations in the Medni Rid area (green columns, see also *fig. 11*) with copper ore samples from Rudna Glava in western Serbia and Late Neolithic and Chalcolithic copper objects from sites indicated in fig. 12.

Lab no.	Site	Object	Context	Period	Subperiod
HDM 1930	Devnja	Hammer axe	Grave 23	LC	Varna II–III
HDM 1946	Durankulak	Bracelet	Grave 389	LC	Hamangia IV
HDM 1976	Durankulak	Bracelet	Grave 29	MC	Hamangia IV
HDM 1980	Durankulak	Bracelet	Grave 321	LC	Varna I
HDM 1988	Durankulak	Bracelet	Grave 739	LC	Varna
HDM 1994	Durankulak	Bracelet	Grave 672	LC	Varna I
HDM 2005	Durankulak	Finger ring	Grave 545	EC	Hamangia IV
HDM 2017	Durankulak	Bracelet	Grave 262	LC	Varna
HDM 2023	Durankulak	Bracelet	Grave 447	LC	Varna I
HDM 2024	Durankulak	Bracelet	Grave 447	LC	Varna I
HDM 2091	Tell Ruse	Borer		LC	
HDM 2127	Goljamo Delčevo	Borer		LC	Varna I
HDM 2716	Smjadovo	Borer		LC	
HDM 2125	Goljamo Delčevo	Borer		LC	Varna I
HDM 1922	Tell Ruse	Chisel		LC	
HDM 1947	Durankulak	Bracelet	Grave 395	LC	Varna
HDM 1949	Durankulak	Bracelet	Grave 2012	LC	Varna III
HDM 1962	Durankulak	Finger ring	Grave 514	LC	Varna II–III
HDM 1965	Durankulak	Bracelet	Grave 253	LC	Hamangia IV
HDM 1968	Durankulak	Bracelet	Grave 275	LC	Varna I
HDM 1973	Durankulak	Bracelet	Grave 317	LC	Varna II–III
HDM 1974	Durankulak	Finger ring	Grave 679	LC	Varna I
HDM 1980	Durankulak	Bracelet	Grave 321	LC	Varna I
HDM 1993	Durankulak	Bracelet	Grave 660	LC	Varna I
HDM 1995	Durankulak	Bracelet	Grave 672	LC	Varna I
HDM 2000	Durankulak	Finger ring	Grave 460	LC	Hamangia IV
HDM 2002	Durankulak	Finger ring	Grave 496	LC	Varna I
HDM 2008	Durankulak	Finger ring	Grave 514	LC	Varna II–III
HDM 2014	Durankulak	Bracelet	Grave 533	LC	Varna
HDM 2018	Durankulak	Bracelet	Grave 291	LC	Varna I
HDM 2028	Durankulak	Finger ring	Grave 454	LC	Hamangia IV
HDM 2031	Durankulak	Finger ring	Grave 506	LC	Hamangia IV/ Varna I
HDM 2137	Durankulak	Finger ring	Grave 496	LC	Varna I
HDM 2062	Tell Ruse	Borer		Uncertain	
HDM 2063	Tell Ruse	Borer		LC	
HDM 2085	Tell Ruse	Borer		LC	

Lab no.	Site	Object	Context	Period	Subperiod
HDM 1483	Selevac	Copper prill		EC	Hamangia III
HDM 1494	Selevac	Copper prill		EC	Hamangia III
HDM 2702	Dăržanica	Heavy axe		MC	End MC probably contempory with Plocnik
HDM 1481	Selevac	Malachite		EC	Hamangia III
HDM 2036	Durankulak	Spiral ring	Grave 506	LC	Hamangia IV/ Varna I

Table 4. List of copper objects analysed by Pernicka et al. (1997) with a preliminary chronological classification indicated by the column 'period'. More precise dates of the contexts at Durankulak, summarised in column 'subperiod', became available through Todorova (2002). Only 5 out of 41 objects date to the Varna II–III period to which also the cemetery Varna I belongs.

associated with very early finds from the Hamangia IV period to Varna I as defined by Todorova (1978). She relates Hamangia IV to the Gradac phase in Serbia, which may well be partially contemporary with the Karanovo IV contexts of Akladi Cheiri (Leshtakov et al. this volume, 89–120). Todorova (2002) divides the Varna culture into three phases but admits that it is difficult to distinguish between phases II and III. Accordingly, most graves are designated either as Varna I or as Varna II–III for which she sees the closest parallels in the cemeteries of Devnja and Varna I.[10] Since the absolute dates of the Varna I cemetery can now be securely fixed at around 4600 BC for the beginning and around 4300 BC for the end (Krauss et al. 2017), this means that the Varna I period must be dated earlier and would thus overlap with Karanovo V, again in line with Akladi Cheiri where Leshtakov et al. (this volume, 89–120) call it Early Chalcolithic and date it between 5000/4900 to 4500 BC.

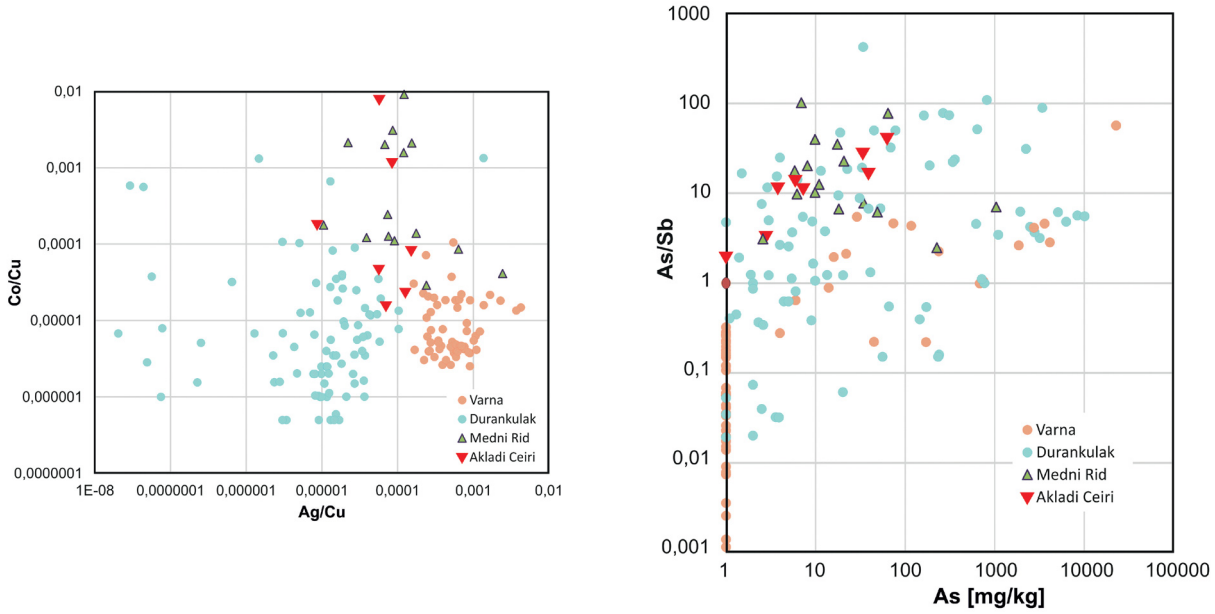
In this context, it is worthwhile to note that the copper objects from Durankulak and Varna distinguish themselves in terms of trace element concentrations (*fig. 16*). Two conclusions can be drawn from these diagrams:

(1) The copper objects from the Durankulak and Varna cemeteries vary in their chemical compositions and can be separated from each other geochemically (specifically by their silver concentrations). The trace element contents of the objects from Durankulak are variable and can be classified into several compositional groups (see Pernicka et al. 1997), which is not surprising considering the long-lasting use of the burial site. In contrast, the copper objects from Varna I are compositionally relatively homogenous, at least in their silver and cobalt concentrations. Arsenic is generally very low with a few outliers that may derive from another deposit.

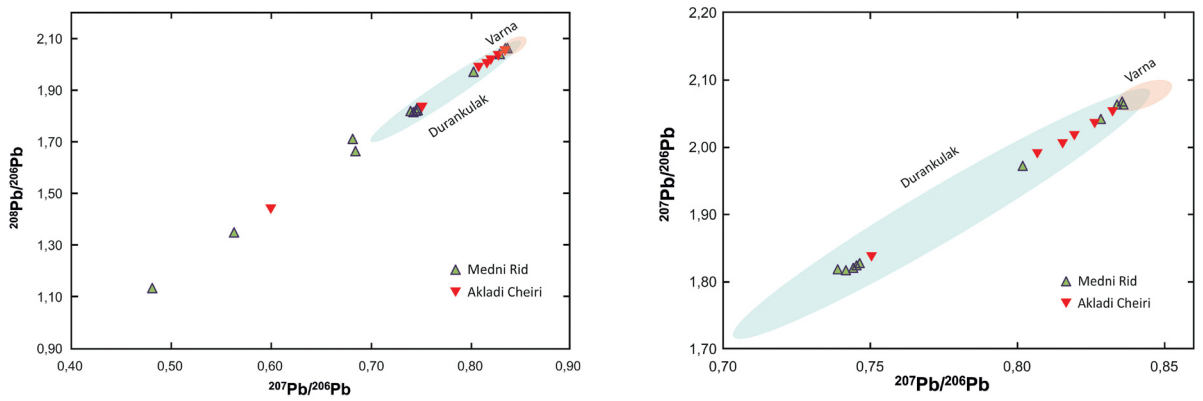
(2) The copper ores from Medni Rid and the chalcolithic settlement of Akladi Cheiri match each other, but are consistent only to a certain extent with the examined copper objects from Durankulak while Varna I is clearly different, specifically the cobalt contents are higher and antimony contents lower.

This is confirmed by the lead isotope ratios (*fig. 17*) in that they are much more homogenous in the samples from Varna, whereas the copper objects from Durankulak indicate large variations and only partially overlap with Varna – even if they are clearly lower than in Medni Rid. Especially from fig. 17 (right) it becomes clear that, for the Varna objects, much like the results for the trace element patterns, Medni Rid is an unlikely source for the copper. More likely the copper derives from other, geochemically similar raw material sources. In particular, the copper deposit of Stara Zagora – but also Ai Bunar and Maidanpek as well as Zidarovo and Varli Bryag – could have

10 Note that this is the designation of the cemetery excavated by Ivanov (1978) to distinguish it from another, slightly earlier burial site Varna II.



Figs. 16. Logarithmic diagrams of Ag/Cu versus Co/Cu (a) and As versus As/Sb (b) of the secondary copper ore samples from the mountainous region of Medni Rid and the Akladi Cheiri settlement compared with the chalcolithic metal objects from Durankulak (n=86) and Varna (n=89). Data sources are Pernicka et al. (1997) for Durankulak and <http://oxalid.arch.ox.ac.uk/Bulgaria/Bulgaria.html> (last access 11.11.2016) for Varna.



Figs. 17. Diagrams of ^{206}Pb normalised isotope ratios from the analysed copper samples from the area under study (Akladi Cheiri settlement and Medni Rid mineralisations) compared with the isotope fields of the analysed copper objects from the burials of Durankulak and Varna in full scale (a) and a detail of the diagram (b).

contributed. There are numerous overlaps with Durankulak which appear all the more interesting in terms of the compositional groupings by K. Dimitrov.[11]

Fig. 18 shows the lead isotope ratios from Durankulak, which partially correspond to these groupings. Of these, 'Durankulak A' corresponds to Dimitrov's metal group A1–A3 and 'Durankulak B' to the other six groups (Dimitrov 2002, 135 fig. 151b). 'Durankulak B' appears quite homogenous in terms of lead isotope ratios, which may eventually allow the identification of the geological source. The isotope composition of 'Durankulak A' shows similarities to those of Akladi Cheiri and the Medni Rid deposits. As discussed above, we can safely claim that one of the metal groups from

11 The examination of the copper implements from the Neolithic to Late Copper Age burials and from more than 1,200 graves from the entire Durankulak necropolis yielded numerous compositional types of copper. K. Dimitrov distinguishes seven metal groups, from which two (C2-C3/A4-C1) were analytically difficult to differentiate (Dimitrov 2002, 135 fig. 151).

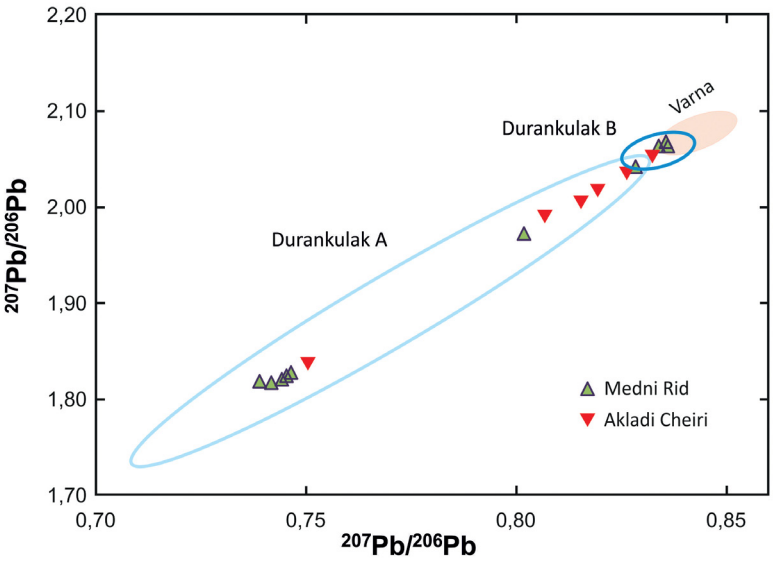


Fig. 18. Diagram of the ^{206}Pb normalised isotope ratios of the analysed copper samples from the surveyed area (Akladi Cheiri settlement and Medni Rid occurrences) compared with the isotope fields of several analysed copper object from the burials of Durankulak and Varna. They show a matching distribution of copper ores to the objects from Durankulak A. Durankulak A corresponds here to Dimitrov's group A1–A3, Durankulak B to the groups D1, D3, ED2, C2B and A4–AC1.

Durankulak matches the typical features of Medni Rid copper ore and that group A can be related to these deposits.

In summary, during the Chalcolithic of southeast Bulgaria several raw material sources in the mountainous region of Medni Rid were exploited for small-scale local copper production. This region, with its secondary copper ore, did not serve as the major centre for raw material and metallurgy for the rich sites of north-west Bulgaria as previously thought (e.g. Todorova/Vajsov 2001, 7), but it provided at least one metal variety for the Durankulak region but not for the Late Chalcolithic cemetery of Varna I.

It seems that the raw material deposits of Medni Rid are the first that were exploited for green minerals and even for copper production at the transition from the 6th to the 5th mill. BC. Neighbouring settlements such as Akladi Cheiri, Budzhaka and Alepu as well as Hadzhidimitrovo and Dana Bunar 2 used the easily accessible copper ores, which must have been exposed on the surface. Due to the rather low copper contents in most ore pieces, only a small amount of metallic copper could be smelted. Nevertheless, it must have been more than just for domestic use, because this copper with a characteristic geochemical fingerprint reached Durankulak in northeast Bulgaria and Dăržanica near the Iron Gates of the Danube. Maybe copper minerals were also exported for other applications as indicated by three finds from Selevac in eastern Serbia. As the demand for copper increased with time, other deposits with much higher copper yields were exploited (e.g. Maidanpek and Ai Bunar but probably also others).

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Raiko Krauss, Ernst Pernicka, Kalin Dimitrov, René Kunze, and Petar Leshtakov

The Transregional Significance of the South-East Bulgarian Copper Deposits

Keywords: Chalcolithic, copper production, south-eastern Europe, prehistoric mining

The investigations in the region of the copper deposits at Varli Bryag, Rossen and Medni Rid have shown that settlement activity began in the Late Neolithic at the latest. Finds of copper minerals at the sites Akladi Cheiri, Budzhaka and Alepu also demonstrate the use of copper ore from the first half of the 5th mill. BC onwards. Since the beginning of the Neolithic in south-eastern Europe, one can observe a preference for green minerals such as nephrite, serpentinite and jadeite, but also malachite and azurite, for the production of jewellery. Thus, the exploitation of copper ore in our region begins with the mechanical processing of green copper minerals to form small beads and objects with amulet character. This may have eventually resulted in smelting and processing of copper prills at the site of Akladi Cheiri by the Late Neolithic as indicated by metallurgical remains such as fireplaces, ceramic sherds strongly fired secondarily, and crucibles with adhering copper slag with enclosed copper particles (*fig. 1*). From the same site derive two small copper pins that prove the use of copper implements as early as 5000 BC (*fig. 2*). The settlement of Akladi Cheiri is thus one of the earliest records for extractive copper metallurgy, similar to Belovode (Radivojević et al. 2010), underlining the early spread of copper metallurgy in the Balkans. Based on the observations made at both sites in the central Balkan region and on the Bulgarian Black Sea coast it may be assumed that the cultural and technological development during the Neolithic began already at the end of the 6th mill. BC culminating in the development of an extractive copper metallurgy throughout the entire Balkans.

During intensive field surveys, substantial traces of pre-industrial mining in the form of huge open casts, sunken shafts, and waste dumps as well as remnants of smelting activities were recorded at various sites in the study area. Surface finds from these sites suggest, however, that large-scale extraction of copper ore began only with the beginning of the Greek 'colonisation' along the western Black Sea coast. Not a single open-cast mine could safely be assigned to prehistoric times, even though a charred wood from a slag block from the site of Kyumyurlaka was radiocarbon dated to the transition from the 4th to the 3rd mill. BC (Kunze et al. 2018, 611–616). Unfortunately, the find context of this piece is uncertain (see Leshtakov et al., in this volume, 327–390, no. 26) and, moreover, the date refers to a period in which there is a definite decline in copper production in south-eastern Europe as indicated by the scarcity of copper finds from this period. This raises the question of how the exploitation of the south-east Bulgarian deposits, especially in the period of the 'metal boom' during the 5th mill. BC was organised. Despite intensive modern industrial mining, copper ores can still be found in considerable quantities on the surface. The lack of mining traces that can reliably be dated to the Late Neolithic, Chalcolithic or the Bronze Age may be explained by abundant outcrops that could be collected and worked on the surface or at shallow depth without deeper interventions.



Fig. 1. Pyrotechnical installation at the site of Akladi Cheiri.



Fig. 2. Two copper pins from the site of Akladi Cheiri.

It is quite possible that the ancient opencast mines could have permanently destroyed traces of near-surface prehistoric mining, but at the latest by the modern industrial mining, as it is also assumed for the mining districts of Bor and Majdanpek in eastern Serbia (Pernicka et al. 1993). In view of this situation, the dating of the deep shafts of Ai Bunar in the Srednogorie to the Copper Age postulated by Chernykh must once again be critically questioned (Черных 1978). Only in three of the shafts chalcolithic finds were made, and unlike in Rudna Glava, these are not complete vessels, which can be considered as a kind of sacrifice in return for the extraction of copper ore. The settlement considered to be related with the mine of Ai Bunar is located at a distance of 5km to 6km and cannot be directly linked to the shafts. Furthermore, the contexts of two heavy copper implements allegedly found in the area of the shafts of Ai Bunar must also be critically evaluated because they belong to post chalcolithic tool types. These critical remarks about the chalcolithic date of the major mining works at Ai Bunar do not put into question the exploitation of the site in the 5th mill. BC. It is only questionable if at this early stage of mining, exploitation with large-scale shafts was indeed practised. It seems quite possible that the gathering of native copper and rich minerals on the surface may have been sufficient.

However, the importance of the deposits of Varli Bryag, Rosen and Medni Rid is evident in the catchment area where copper tools and implements with their specific geochemical signatures occur. In the cemetery of Varna I, as well as in the north-east Bulgarian tell settlements of the Copper Age, the items were produced predominantly from copper varieties of these deposits (Pernicka et al. 1997; see also Kunze/Pernicka, this volume, 291–418). In the known cemeteries of the late Copper Age in north-east Bulgaria, the percentage of copper supply from the ore deposits along the south-east Bulgarian coast (mainly Medni Rid and Rosen) has been quantified to about 32.6% for Durankulak and even 55.1% for Varna (Dimitrov 2002; Димитров 2007, 61). Of these, 38.5% (Durankulak) and respectively 33.7% (Varna) can be assigned directly to the Rosen deposit (*fig. 3*). If we compare these quantities with the copper produced in the Ai Bunar area (38.8% for the Varna area graveyards and 28.9% for the Durankulak necropolis),

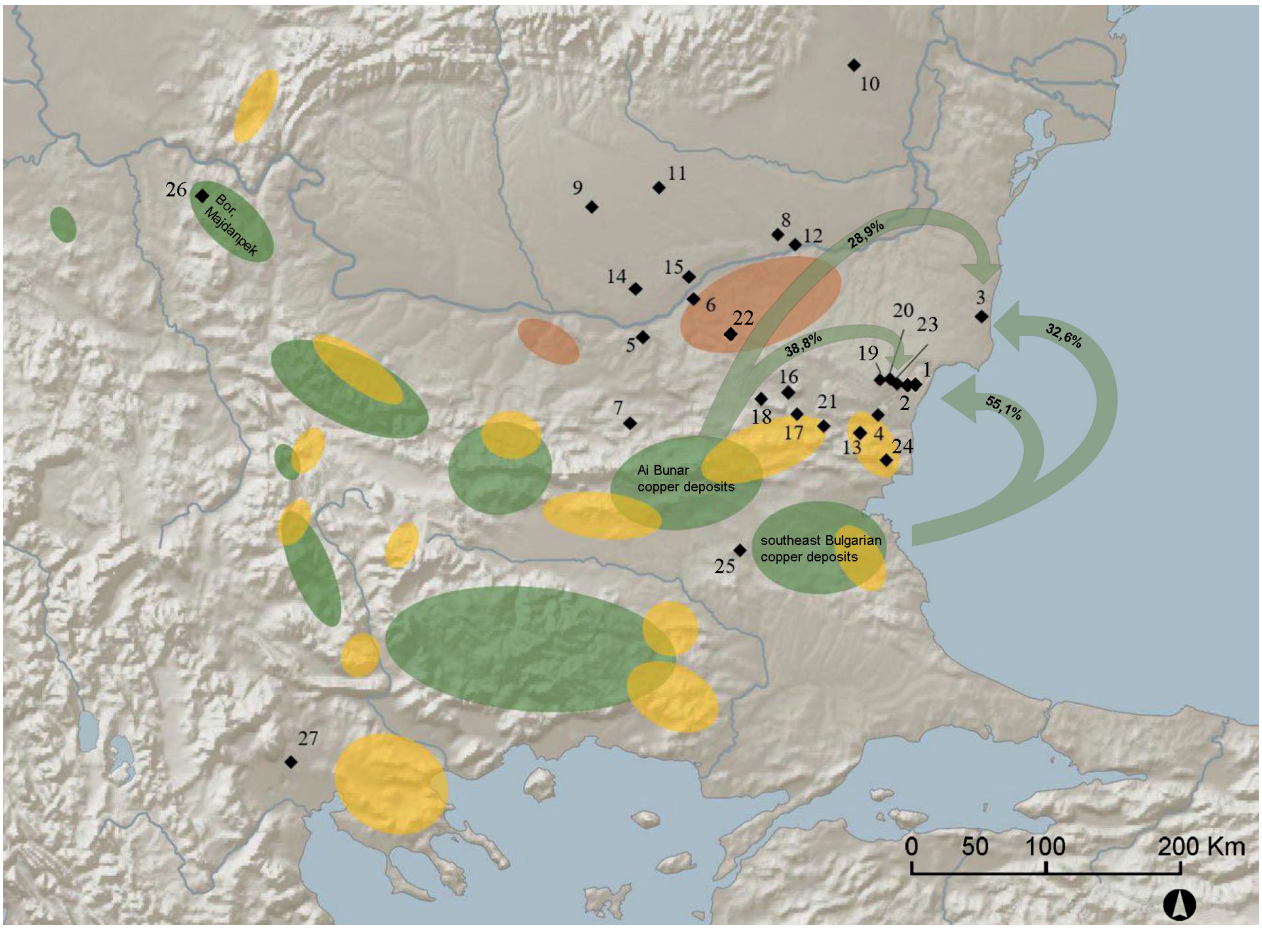

Fig. 3. Resource situation in the 5th mill. BC in the eastern Balkans (after Leusch 2016; Krauss 2017). Green: copper deposits; yellow: gold sources; brown: deposits of flint usable for the production of super blades. Important Late Chalcolithic settlements and burial sites with gold finds: 1 Varna I, 2 Varna II, 3 Durankulak, 4 Dalgopol, 5 Krivina, 6 Ruse, 7 Hotnitsa, 8 Sultana-Malu Roşu, 9 Balaci-Măgura, 10 Lungoci, 11 Vlădiceasca, 12 Vărăşti, 13 Goljamo Delchevo, 14 Vitaneşti, 15 Pietrele, 16 Targovishte, 17 Ovcharovo, 18 Polyanica, 19 Reka Devnya, 20 Devnya, 21 Sava, 22 Radingrad, 23 Poveljanovo, 24 Zavet, 25 Drama, 26 Belovode, 27 Aravissos Yannitsa.

the importance of copper deposits of the southern Bulgarian coast stands out. A significant reason for this may be its better accessibility, especially if contacts are made by sea.

This resembles a situation similar to the supply of gold to the chalcolithic societies in the 5th mill. BC. Considering the Varna finds, it is apparent that gold served as a major indicator of individual wealth. The new evaluation of the internal chronology of the Varna cemetery (Krauß et al. 2017) provides evidence that at the beginning gold items rarely appear in the graves while the number increases exponentially throughout during the development of the burial place. The prospection and exploitation of gold represent an invention that may be directly linked to the appearance of gold metallurgy during the Chalcolithic. Contrary to the previous assumption that the gold from Varna was partially exploited by hard rock mining (Hartmann 1970, 42; 1982, 41), the new analyses revealed no evidence that this activity was practised for gold exploitation. Instead, the gold objects from Varna reveal a chemical pattern that clearly points to placer gold exploitation from stream sediments (Leusch et al. 2016; 2017). Platinum, palladium and tin are considered as characteristic trace elements that indicate the exploitation of such gold placers from stream sediments. Since primary gold deposits are usually not associated with platinum group minerals and tin their presence in prehistoric gold is usually explained by weathering of different rock types in a certain region that

is drained by a river system. Some minerals, like gold, platinum group minerals and cassiterite (tin oxide) are resistant to weathering and accumulate in river sediments, where they are enriched to heterogeneous placers due to their high specific gravities (e.g. Hauptmann et al. 2010; Tsintsov 2013; Leusch et al. 2014). Thus, by panning for gold in rivers and streams it is unavoidable to include other heavy accessory minerals. Even large gold nuggets are generally not pure but may contain physically incorporated minerals such as quartz, ilmenite or magnetite, but also commodity minerals such as cassiterite, platinum group minerals, and locally even the copper minerals azurite and malachite. On melting of the gold, these heterogeneously composed placers are homogeniszed by and melting and then cast into artefacts. Since it can safely be assumed that gold dust (an accumulation of micronuggets) was melted under reducing conditions in a crucible covered with charcoal, many impurities dissolve in the gold matrix and form specific trace elemental patterns that we may recognise in the artefacts. In recent studies, several of these placer occurrences have been documented in eastern Bulgaria (Bachmann/Tsintsov 2003; Tsintsov 2013; Tsintsov/Popov 2012). While it was previously assumed that the gold was imported from distant regions (Hartmann 1982, 40; Lichardus 1988, 106), these new findings rather point to the regional potential for gold supply during prehistory.

Moreover, the chalcolithic economic networks that can be recognised from the various commodities at Varna also support a more regional supply of gold. For example, there is the yellow flint from which the long, fragile blades, the so-called superblades, were formed (Manolakakis 2005). The raw material derives from deposits in north-east Bulgaria from the region around the town of Razgrad, where it was mined and worked in 'specialised workshops' (Sirakov 2002, 221). So here we are not dealing with the control of a small social elite over a mine, but with broad networks that provide the supply of materials from various sources far from each other.

Although the sea level of the Black Sea in the 6th and 5th mill. was still well below today's level (Brückner et al. 2010; Fouache et al. 2012), water transport can still be considered as one of the most important distribution channels for metal. The finds of Akladi Cheiri suggest that ore processing took place directly on site. For a production of copper appliances on a large scale, however, not only the evidence of the production facilities is missing but also the large settlements. Significantly, there is not a single tell settlement or even a larger site of the Copper Age in the wider surrounding of the copper deposits. The nearest tell settlements of Kameno and Kozareva Mogila are located at distances of about 45km and 65km, respectively.

There remains a phenomenon, which we are unable to explain at present: The network for copper supply from the south-east Bulgarian copper deposits seems to have stretched almost exclusively to the north. The adjacent region of the southern Turkish part of Thrace cannot only be considered as relatively well-researched, but it was via the Black Sea coast at least in principle as well connected to the copper sources as the coastal areas in northern Bulgaria. The nearest well-researched settlement site of Aşağı Pınar near Kırklareli was abandoned at 4800 BC, precisely at the time when an exponential increase in demand for metal in the Balkans is observed (Parzinger 2005). A similar situation is known from the numerous Late Neolithic settlements found around the Marmara Sea, none of which survived the middle of the 5th mill. BC. The only as yet unexplored settlement in north-western Anatolia in this period is the site of Alacalıgöl, but it is already situated south of the Dardanelles, in the Troad (Krauß 2017, 81–83). Accordingly, the copper deposits of Rosen, Varli Bryag and Zidarovo are located at the edge of the actual cultural centres of the Chalcolithic.

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PREHISTORIC MINING AND METALLURGY AT THE SOUTHEAST BULGARIAN BLACK SEA COAST

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