

Are the 'new' AMS Varna dates older?

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ABSTRACT

The paper elaborates on the AMS dating results obtained for the Chalcolithic cemetery near Varna, located on the western Black Sea coast in northeastern Bulgaria. The focus here is not on the comparison between absolute dates acquired for various sites from the middle and late Chalcolithic period in the region. It is rather on the examination of the main approaches towards suggested chronological frameworks. Divided into three parts, the text reviews regional methods for proceeding conventional radiocarbon dates (II A) and such, related to the later AMS measurement of bone collagen (II B). Both approaches are considered as deserving more attention with regard to the problematic aspects that may affect the acquisition of reliable results. The 19 new AMS Varna dates are found important for chronological revisions. However, at this stage they alone are not considered sufficient for inarguable modifications of the schemes (III). Along with identification of major factors that should be taken into account when dealing with the chronological debates in the specified region, strategies for solving some of the issues are also suggested.

KEYWORDS

Radiocarbon dating, AMS, Varna, Chalcolithic period, Eastern Balkans

Introduction

Chronology is fundamental for the study and interpretation of past events or cultures. However, attempts to establish precise dates or periodizations can prove to be extremely difficult. The study of Balkan prehistoric societies from the Chalcolithic period (Eneolithic or Copper Age) is built around the concept of *archaeological cultures* or *cultural complexes*. Their internal periodization and relative chronology are based on typology (mainly stylistic characteristics of the artefacts) and stratigraphic observations. This approach may result in highly variable personal opinions, ranging from plain notional differences to major methodological disparities. It remains uncertain to what extent such reconstructions of the past are less unbiased and whether, despite their implementation for decades, they withstand new scientific evidence.

Scientific dating methods, on the other hand, are sometimes considered as providing reliable or 'correct' absolute dates, sufficient for building chronologies. These approaches also raise certain issues, starting with the collection and sampling of materials and extending to the implementation of statistical models for interpretation of results.

The application of novel scientific techniques in eastern Balkan regions, where the main approaches hitherto have relied on relative chronology, can be problematic. Most samples were dated by the conventional (beta counting) technique and the dates are accepted or rejected depending on their correspondence to stratigraphy and currently adopted chronological frameworks. Thus, the application of new AMS radiocarbon dates becomes a real challenge: they are compared both to the relative chronology based on ty-

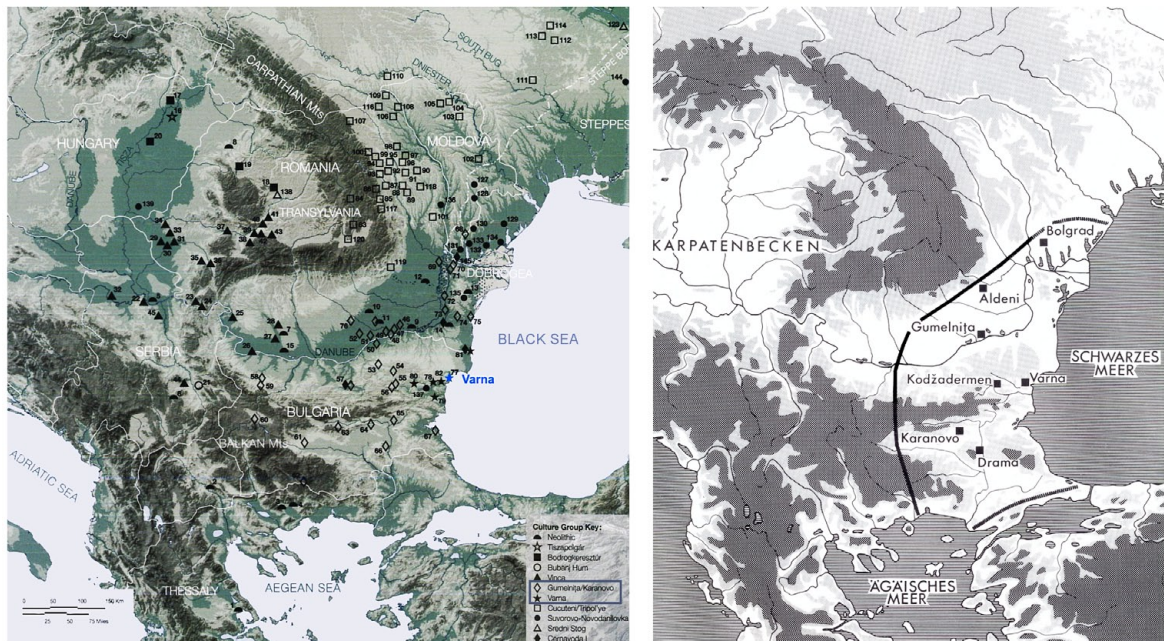


Fig. 1. Map of prehistoric sites and cultures on the Balkans and the location of Varna (after Anthony, Chi 2010, left). Cultural ranges according to earlier studies (after Lichardus 1988, Abb. 43, right)

Обр. 1. Карта на праисторически обекти и култури на Балканите и местоположение на Варна (ляво, по Anthony, Chi 2010). Културен обхват на КГК VI в по-ранни публикации (дясно, по Lichardus 1988, Abb. 43)

polological evidence, and to the absolute chronological frameworks established on the basis of conventional (beta counting) radiocarbon dates. Often, because of discrepancies between the two sets of dates, the new AMS dates are treated as unreliable and are therefore disregarded.

A good example of this tendency is the first AMS radiocarbon dating of the Chalcolithic cemetery near Varna, Bulgaria (fig. 1). Released six years ago, it had not yet been officially debated in published form by local researchers. This contrasts with the works of foreign scholars, who already use the dates as a basis for modifications of the entire chronology of the eastern Balkans and, therefore, of Southeastern Europe.

There is an urgent need to challenge both of these approaches – in terms of the revision of current chronological frameworks, as well as considering the importance of the site in the context of major research problems related to the Chalcolithic period. This paper aims at comprehensive examination of the main chronological approaches and details of the dated samples, together with a clarification of discrepancies and an evaluation of the reliability of the results. A number of factors that have not been considered hitherto will be highlighted and the attention will be drawn to additional data that have a bearing on the problem. Proposed recent modifications of the chronology will be evaluated according to the availability and sufficiency of complex evidence. Finally, suggestions towards possible solutions of the problem will be offered.

The lack of dialogue between the followers of the major approaches is certainly not in favour of a solution. It calls for examination of the available data from a different perspective, along with identification of major factors that should be taken into account when dealing with the chronological debates in the specified region.

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The 'problem' of the dating of Varna cemetery

The cemetery near Varna illustrates the complexity of the problem and the way local archaeological and general scientific approaches may sometimes appear in conflict. In the light of the new AMS dates, the following key questions need to be addressed:

- Could factors inherent to the site or the sampled material have caused the discrepancy in dating?
- Could the methodological approach be the reason for the discrepancy between the two chronological frameworks?
- Is the further interpretation of the new results (cf. Chapman et al. 2006; Reingruber, Thissen 2009) well founded and how can these results be confirmed?

As a complex process, starting well before the actual measurement of the sample ratio, the radiocarbon dating procedure involves three basic steps – the history, the investigation and the interpretation (Bronk Ramsey 2008, 266, fig. 2). This last mentioned consists of: estimation of the uncertainties, characterization of the radiocarbon content, calibration (which includes data about primary reservoirs, diet and lifecycle of the organism), determination of the date of death, analysis of the archaeological information and definition of the chronological framework. In the present paper – starting and concluding with the Varna site – this is accepted as a logical structure to follow when examining dating results and their implementation in building prehistoric chronologies.

I. Characteristics of the site

Significance and chronological position

The Varna cemetery was investigated between 1972 and 1991, revealing 310 graves (Ivanov 1988, 49; Slavchev 2009, 105, 110). The generated enormous interest was primarily because of the abundance and variety of the grave goods – only five of the graves contained no finds at all. The site attracted international attention because of the very large, and currently the earliest-known, assemblage of gold objects, suggestive of an unexpectedly advanced metallurgical technology and the high socioeconomic status of the population in the region. Excavations have revealed more than 3,000 gold artefacts (the total weight of which exceeds six kilograms), more than 160 metal artefacts, 230 flint tools, 650 vessels, 1,100 *Spondylus* and 12,200 *Dentalium* shell adornments and numerous other small finds (Slavchev 2009, 113-115). On the basis of typology, the graves were attributed to the late Copper Age Varna culture from the second half of the late Chalcolithic, chronologically correspondent to the Kodzhadermen-Gumelnița-Karanovo VI (KGK VI) complex (Ivanov 1980, 28; 1983). The presented chronological framework, however, is ambiguous. It includes a 'conventional' range, which spreads between '3500 and 3200 BC', and 'calibrated dating, based on ¹⁴C measurements' which covers the 4600–4200 BC period (Ivanov 2000, 12). Although it is meant to be impartial, this indication is not based on radiocarbon dated materials from the site. It conforms to the general periodization of the Chalcolithic period, while the source of the chronological framework adopted is not indicated.

Regarded as a key site from the late Chalcolithic period in the region, the cemetery not only allows for interpretations of mortuary practices and symbolic activities (Иванов 1975; Иванов 1979; Marazov 1988; Marazov 1991; Lichardus 1991; Nikolov 1994; Ivanov, Avramova 2000), but the great interest in the production of metal and especially gold objects has also resulted in researches on the emergence of wealth and the significance of gold as a central token of value. These studies examined the site in the context of early met-

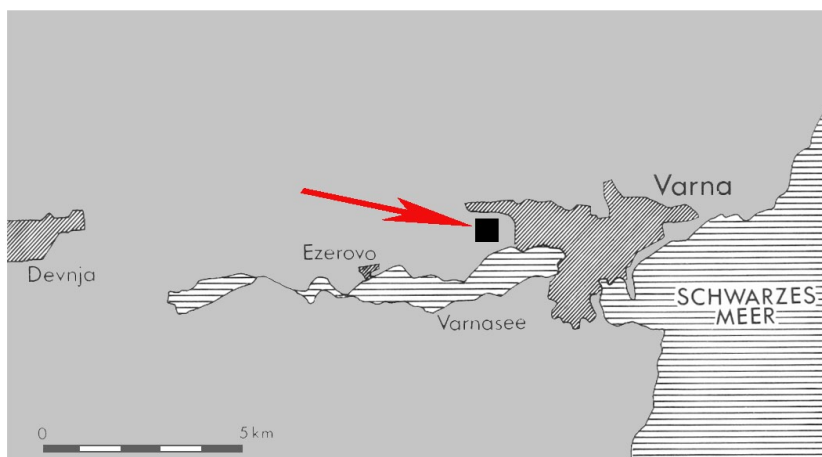


Fig. 2. Location of the site at the lake-shore (after Ivanov 1988, Abb. 33, above and Google Earth, below)
 Обр. 2. Местоположение на обекта до брега на езерото (по Иванов 1988, Abb. 33, горе и Google Earth, долу)

allurgy; 'social power'; the organization of society and development of 'cult centres'; the significance of salt, and many other aspects (Радунчева 1986; Тодорова 1992; Ivanov 1983; Renfrew 1978; 1986; Pearson 1993, 207).

Along with its importance for the characterization of the suggested Varna culture, the cemetery may also have a bearing on the examination of certain concepts related to the understanding of the later, final Chalcolithic stages and the problematic 'transitional period' to the Early Bronze Age. These include suppositions about factors such as climatic changes; 'cultural infiltrations' or later 'migrations' of 'steppe population'; and results, such as the abandonment of the settlement mounds and the eventual migration of the Varna population to the south (see Тодорова 1986, 39; summary in Slavchev 2009, 120). Bearing in mind the presumed retained old customs or continuation of elements of the Varna style, the possibility for precision of the cultural and chronological position of the site and the culture would be of key importance, along with eventual clarification of the interrelations with other contemporaneous 'cultural complexes'.

A possible change to the dating of the site might affect the interpretation of the mentioned questions. Given the broad, overall time-range of the late Chalcolithic period in the region set between 4500/4400 and 4100/3800 BC by Boyadziev (1995), the AMS radiocarbon dating of human bones from the Varna cemetery suggests a somewhat earlier time range between c. 4560 and 4450 BC (Гайдарска 2011; Chapman et al. 2006; Honch et al. 2006; Higham et al. 2007; Higham et al. 2008, Honch et al. in press/2007¹).

1 The publication in press, submitted in 2007, was kindly provided by the editor Dr L. Nikolova.

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Geographical characteristics of the region

Varna is located on the western Black Sea coast, in northeastern Bulgaria. The region has been variously considered as part of the eastern Danube River plain (Стефанов 2002, 30, 43), or as a separate coastal area influenced by the sea (Динев, Мишев 1980, 27, 107-108; Михайлов et al. 1989, 31). The plain is connected to the Great Russian Steppes and the Middle Danube region, and is widely open to the Black Sea (Динев, Мишев 1980, 104; Колев 2002, 13; Стефанов 2002, 30). The coastal region is also viewed as a crescent-shaped area between the Steppes and Anatolia, containing no geographical barriers to movement of people or exchange of information (Лещаков 2006, 144, 146). The relief is that of a plain, with hilly and plateau-like areas nearer the sea. The area is either referred to the Temperate Continental climate zone, with prevalent steppe characteristics to the east, or to the Black Sea climate zone, which comprises a 20-40 km wide coastal strip (Динев, Мишев 1980, 39; Йорданова et al. 2002, 391).

Location of the site

The archaeological site is located in the western industrial zone of the modern city of Varna, ca. 400-600 metres to the north of the Varna Lake (fig. 2), which during the Chalcolithic was a bay connected to the Black Sea (see below). The cemetery area occupied a terrace at an elevation of 12.50 to 20 metres above present sea level that slopes down toward the water's edge (Ivanov 1988, 49; Slavchev 2009).

Archaeological characteristics

Since complete publication of the site is still in preparation, only general information will be presented here. Of 310 Chalcolithic graves, 105 are disturbed (Slavchev, Boyadzhiev 2011). The graves (which probably were marked in some way) have a rectangular shape with rounded corners and were dug deeper in the central area of the cemetery. Two major groups are defined according to the presence or absence of human remains – common graves (with male skeletons in an extended position on their back and female skeletons in a contracted position lying on their right side) and cenotaphs (Slavchev 2009, 110–112). Because of the absence of cremations and the presence of identical burial structures, the definition of the cemetery as 'bi-ritual' (Ivanov 1980; Ivanova 2008) is not accepted here (see Sprague 2005). The original position of the body is ascertained in 160 cases and the sex and age of the deceased is determined for 62 individuals. With only eleven exceptions, the heads face northeast (Slavchev 2009, 110–112).

Forty-seven graves contain no human remains and are interpreted as burials dedicated to community members who perished far away (Best 1984, 150). Three such cenotaphs included clay masks of human faces (suggested as female graves according to the inventory). Some cenotaphs comprised half of the total weight of all grave goods recovered from the cemetery (Slavchev 2009, 113). The pit shapes do not differ from those of the rest of the graves, but some are deeper revealing remains of colouring or textiles and many fragmented bones laid down prior to deposition of the grave goods (Иванов 1979, 95).

The 'Varna culture'

The site is among the main representatives of the Varna culture. Further to the small number of sites and the state of the research, such characterisation may be problematic bearing in mind the various interpretations of what an 'archaeological culture' actually constitutes, and the diverse descriptions of 'cultures', 'cultural groups', 'pottery styles' and

'ethnocultural complexes' in the region (see Стаменова 2003; Панайотов 1985). However, because of the many factors related to dating itself, this problem is only mentioned here.

Authors who consider Varna an independent archaeological culture, define its distribution area as the littoral zone between the Stara Planina and the Danube River – a 30 km wide strip (Тодорова 1978, 9, map 1; Ivanov 1983, 158; Todorova, Tončeva 1975). Generally, the late Chalcolithic is characterized as a period presented in numerous stratigraphically verified contexts with consistent typological contents for each of the phases (Тодорова 1978, 8; Тодорова 1986, 40). It is incorporated in the major periodization schemes for the eastern Balkans, including the complexes of Kodzhadermen-Gumelnița-Karanovo VI (KGK VI) in Thrace, Varna-Bolgrad in the western Pontic area and Krivodol-Salkutsa-Bubani in the central Balkans (Тодорова 1986, 23). Whereas at the beginning of the late Chalcolithic the classical KGK VI complex has developed in northeastern Bulgaria, the maritime region represents the first phase of the Varna Culture. According to H. Todorova during the entire Chalcolithic period in the region there are considerable differences between the high-quality material culture of the coastal Varna and the inland KGK VI complexes (Тодорова 1986, 120-121). The neighbouring cultures are Gumelnița (to the west) and Cucuteni-Tripolie (to the north), defining the territorial range of Varna as limited (the land being restricted between the mountains, the sea and the neighbours who experienced considerable demographic increase [Slavchev 2009, 119]). It should be mentioned, however, that the culture is characterized on the basis of materials from very few sites, some of them – representing unique complexes; and furthermore, other researchers do not accept the definition of the Varna culture, suggesting that it is a coastal variant of the inland Gumelnița culture (cf. Simon 1983).

II. Radiocarbon dates

A. Previously established chronological frameworks

The earliest results of the systematic work on the radiocarbon dating of Balkan prehistoric sites of Yavor Boyadzhiev, published in the 1980s (Бояджиев 1984; 1986; 1987) are considered fundamental for the researches on the regional chronology. The approach is not modified in later works of the author (Бояджиев 1997; Boyadjiev 1988; Bojadžiev 1992; Boyadzhiev 1995; Görtsdorf, Bojadžiev 1996; Bojadžiev 1998; Boyadzhiev, Aslanis, in press²). Since the suggested chronological framework is broadly accepted in the Bulgarian bibliography and is not reviewed in details in foreign studies, some basic statements will be briefly presented below.

In the very early publications it is maintained that the calibration of radiocarbon dates from eastern Balkan sites may be problematic. The specifics of the calibration curves and the short-term variations of ¹⁴C content in the atmosphere are seen as causing an irregular zigzag distribution of the values. Whereas inconsistencies are not found in the major part of the Neolithic sequences, considerable fluctuations are identified for the majority of the dates that are attributed to the Chalcolithic phases. Thus, the calibration of radiocarbon dates from certain periods is considered possible only in broad chronological ranges, their application being reliable only when compared to the specific stratigraphic sequence and depositions.

² Y. Boyadzhiev kindly provided the quoted article in press (Boyadzhiev, Aslanis, in press) and commented on his approach (personal communication, January 2012).

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The estimated similar values for chronologically different materials, or different values for synchronic materials are seen as a result of these variations (*de Vries effects*), suggesting that considerable discrepancies are expected during the periods of shorter fluctuations. Thus, although the calibration is acknowledged as absolutely necessary, and the use of conventional dates is defined as misleading (Бояджиев 1984; 1987; 1997), the dating for the periods with ^{14}C variations ('anomalies') is suggested as applicable only in very wide ranges (300–500 years), making it impossible to compare between single dates (or such from just one settlement horizon) and values from other sites. Hence, the dating in the fluctuation periods is defined reliable when limited only to the frameworks of a culture, whereas internal separation of phases, sites or horizons is considered risky. The radiocarbon dating results are recognised as valuable only in combination with traditional archaeological and other scientific dating methods.

Suggested fluctuations and periods

The analysis of series of dates from Chalcolithic eastern Balkan multi-layered sites made by the quoted author (Бояджиев 1987, 17–24) suggests discrepancies between the radiocarbon dating results and both the relative chronology based on typological characteristics and the stratigraphic sequence. This lack of correspondence (termed an 'anomaly' by Y. Boyadzhiev) is related to a possible decrease (or fluctuations) of ^{14}C in the atmosphere (Bojadziev 1986, 118–119).

The author assumes a number of such anomalies, that practically spread throughout the entire Chalcolithic period and especially during its late phases (Бояджиев 1987, 18–19; Bojadziev 1986, 118–119; Boyadjiev 1988, 206):

The dates from the *beginning of the early Eneolithic period* are defined as stratigraphically consistent – being younger in comparison with the late Neolithic ones.

The *first anomaly* – a 'continuous fluctuation of medium duration' is established in the *middle and in the second half of the early Eneolithic*, with a peak at the beginning of the *middle Eneolithic period*, where the ^{14}C ages are older than those from earlier periods.

In the *second half of the middle Eneolithic* the values decrease in correspondence to the stratigraphic sequence, but are still identical to those from the first half of the early Eneolithic.

The first half of the *late Chalcolithic* is included in the second type of registered 'anomalies' – the *short-term variations* – and is considered most problematic. It is suggested that the sharp drops or peaks of values are not recorded in the current calibration curves. In the beginning of the second phase of the late Chalcolithic complex they coincide with Early Chalcolithic dates, and decrease again at the end of the culture. The dates for the middle and late Chalcolithic periods vary considerably, overlaying those from the earlier periods (the late Neolithic and the early Chalcolithic).

In general, the radiocarbon dates from the Chalcolithic period in South-Eastern Europe are seen as revealing considerable discrepancies in comparison to the relative chronology, the latter – considered as founded on reliable stratigraphic contexts and sequences.

Thus, the Chalcolithic period is divided into three phases:

- Early Chalcolithic (4900/4850–4600/4550 BC)
- Middle Chalcolithic (4600/4550 – 4450–4400 BC)
- Late Chalcolithic – from 4500/4450 BC (in the areas of KGK VI and Varna) to 4100–4050 BC, having different ranges in Western and Southern Bulgaria (Бояджиев 1987, 17, 18–19, 20–24; Boyadziev 1995; 1997).

Ovcharovo/Horizon 7	Bln 1366 5745±60 (3795)	-	-
Ovcharovo/Horizon 6	Bln 1367 5775±60 (3825)	-	-
Ovcharovo/Horizon 5 Start middle Chalc.	Bln 1493 5940±80 (3990)	-	-
Ovcharovo/Horizon 3 Very end early Chalc.	Bln 1368 5795±60 (3845)	Bln 1546 5990±80 (4040)	Bark. Rotten building platforms. Beginning of horizon 3.
Azmashka/Horizon 5	Bln 142 seeds barley 5803±150 (3853)	Bln 137 oak 5697±100 (3747)	Bln 147 5219±150 (3269)
Azmashka/Horizon 6	Bln 151 'annual plants' 5829±100 (3879)	Bln 148 'annual plants' 5760±150 (3810)	-
Azmashka/Horizon 7	Bln 143 seeds 5737±150 (3787)	Bln 150 seeds 5630±159 (3680)	Bln 13 6oak 5840±100 (3890)
Azmashka/Horizon 8	-	-	-
First half early Chalc. (4900-4550 BC)	-	-	-

Table 1. Example for the approach followed by Y. Boyadzhiev: distribution of dates from early and middle Chalcolithic multi-layered settlements

Табл. 1. Пример за подхода, следван от Я. Бояджиев: дати от пластове от ранен и среден халколит в селищни могили

Example for the approach

Since the use of radiocarbon dates is conditioned by their correspondence to the stratigraphy, the relative chronology and typological characteristics, and the specifics of the sampled material, the early-middle Chalcolithic dates from multi-layered sites (table 1) will be used here as an example of the traditional consideration of the values (based on Boyadjiev 1988, 203–205).

In *Azmashka* tell there are no dates for the first half of the early Eneolithic. The earliest Chalcolithic horizon in the settlement mound (*horizon 8*), defined as belonging to the second half of the early Chalcolithic, is not dated. The earliest three dates – two from seeds and one from oak are obtained for the next early Chalcolithic horizon (*horizon 7*), resulting in variable years BC. The figures for the later, 6th *Azmashka* horizon (annual plant samples), although being more consistent when compared to each other, are also considered generally problematic, showing an increase of the age instead of the expected younger values. The same tendency is observed for the next, the latest early Chalcolithic *Azmashka* horizon (*horizon 5*), the result from one of the samples (Bln 147), which differs from the rest, being defined as incorrect. The other two dates from the 5th horizon are found 'close' to those for the sixth and 'completely correspondent' to those from the seventh. However, when the specifics of the material are taken into account (oak and barley), the author sees the distribution of the dates of the three early Chalcolithic *Azmashka* horizons as following a tendency towards ageing. The latter is particularly evident with dated seeds. Again, the observed tendency is related to decreasing concentration of atmospheric radiocarbon, seen as supported by dates from other sites (Boyadjiev 1988, 203).

The arduous work for comparing every single result to the rest of the dates, the stratigraphy of each of the sites and the characteristics of the material culture is intended to follow

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very logical lines. It is combined with expert knowledge of the archaeological contexts and sequences in the entire Balkan region, and careful consideration of the sampled materials. The author is aware of the factors that may cause errors in the levels of precision and that condition the interpretation of radiocarbon dates. However, deductions such as 'it is quite logical' or the date is 'obviously wrong' (Boyadjiev 1988, 203–204) represent personal approach which, given the current dating methodology, is unconvincing. Although the selection of dates that should be used in a way eliminates outliers, no other technique is applied to verify the assumptions, the probability and the results (see Bronk Ramsey 1998). Such deductions are made even in cases where three dates have been obtained for a horizon, one of these being excluded as unreliable. Differences between dates from one and the same horizon, or similarities between dates from various horizons, are explained in terms of the specifics of the sampled materials. All discrepancies between the expected values – according to their stratigraphic distribution – are considered a direct result of the shortcomings related to the calibration curves and fluctuations of radiocarbon in the atmosphere (the anomalies indicated above).

Sampled wood

Back to the general topic of beta counting radiocarbon dating, certain specifics should be reminded. Apart from the 'old wood effect' that should be considered when sampling charcoal, the reliability of the results, and especially those from construction elements, can be problematic. Their direct influence on the interpretation, according the described approach, is crucial in building chronologies and establishing correspondence between strata from different sites.

Factors such as stockpiling or seasoning (Miles 2006) are not considered as general problems here. The major issues are related to preservation and possibly misleading attribution of construction elements in multi-layered sites, as well as to analysis of individual samples, wood from mixed fills, or randomly selected single lumps from large piles (see Kuniholm 2001, 36).

The possible variations in making decisions about the characteristics of the sampled wood – archaeological remains of beams or piles – are best demonstrated by some principles of the dendrochronology. The examination of the degree of sapwood preservation, used as a basis for precise felling dates, for estimated felling dates and ranges, or simply as a *terminus post quem* (Baillie 1982; 1995, 23; Miles 1997, 42–45) again demonstrates the uncertainty when exploring wood used in building constructions.

These data should also be interpreted with caution, because if the characteristics of sampled materials are questionable, some of the horizons would not retain their position in the proposed sequence of dates. More attention should also be paid to the materials obtained from 'rotten remnants of the bark of beams' in the wooden dwelling platforms, interpreted as presenting 'the beginning of life in horizon 3' in Ovcharovo (Boyadjiev 1988, 204). It should be mentioned that the survival of a complete sapwood piece in archaeology is defined as 'near-miraculous' (Baillie 1995, 58) and the various possibilities for processing wooden material should also be taken into account. The application of certain techniques for splitting large trees (resulting in elements with completely preserved sapwood or without any) reveals the great age differences between parts of one and the same construction (Baillie 1995, 62). It should also be noted that small posts split from the centre of large timbers resemble short-lived materials ideal for radiocarbon dating, but their dates are older by two or three centuries. In this sense, although the major differentiation between sampled wood

and seeds is well-founded in the longitudinal study of Y. Boyadzhiev, there are yet more factors and resources to be considered in order to verify the proposed interpretations.

Stratigraphic frames and horizons

Traditionally, the relative chronological position of the archaeological strata is considered according to the main periodizations that divide the prehistoric periods (and the development of the archaeological cultures) into three phases – early, middle and late (Тодорова 1986). Other approaches (Nikolova 1999; Parzinger 1993; Krauss 2008) suggest certain revisions and, given the fact that the absolute dates are considered by Y. Boyadzhiev in terms of the three-partite major chronological scheme, one may expect variations in the chronological frameworks (see below).

Nikolova 1999	Final Copper age	4050-3700/3600 BC
Krauss 2008	Late Copper Age – Karanovo VI	4500-4000 BC
Parzinger 1993	Chronological horizons 8-9	Copper age, no absolute dates

Furthermore, there still are discrepancies in the methodology or nominalization, applied by the archaeologists in the region for definition of the stratigraphic levels, layers, horizons or building phases. The latter may result in considerable differences in the description and interpretation of the sites. Currently, the Harris matrix is applied rarely, if at all, and the presentation of the stratigraphy may be highly individualistic (especially in older excavations). Such examples are presented in sites as Azmashka, where the partial reconstructions are included in four main horizons, whereas in others (Golyamo Delchevo) each reconstruction is defined as a new horizon. Yet others, despite their 1,20 m thick layers, are not subdivided into horizons (Cascioarele), (see Boyadjiev 1988, 202, 204–205). Such discrepancies or the lack of commonly accepted approach hinder the attempts to distribute dates in the horizons of a given site and to compare them to typologically similar materials from archaeological strata of other sites.

Calibration and curves

A considerable amount of literature has been published on the need of calibration, the most simple statement among others being that uncalibrated dates are wrong and meaningless (Pollard 2009, 153–154). The researchers who analyse the radiocarbon dates from Balkan prehistoric sites have also accepted the calibration requirement from the very beginning of their studies (Тодорова 1986, 38; Бояджиев 1987, 24). However, the calibration of late Chalcolithic dates from the Balkans was defined as problematic – subject mainly to the anomalies (see above). Given the number of calibration curves and the ‘equally confusing number of statistical interpretations and compilations of the curves’ (Bowman 1995, 45), one may ask whether a mistaken result may be caused by the applied personal approach or by imperfections of the used calibration curves. Furthermore, it becomes harder to consider the calibration curves as ‘truly definitive’ – since revisions of previously established and internationally agreed models are continuously offered (Baillie 1995, 72; see Stuiver et al. 1998).

When analyzing a series of 487 dates from 69 prehistoric Bulgarian sites Y. Boyadzhiev and J. von Górsdorf (1996) apply the calibration curve of B. Weninger, published in 1986. On the other hand, the programme and the calibration curves applied for the new AMS Varna dates are internationally approved later models. Differences may also be seen as

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resulting from the application of the precise, modern curve, which covers wider areas and therefore leaves enough room to take into account possible regional anomalies that may not be indicated in the general record (regional anomalies are considered possible also in recent studies, Boyadzhiev, Aslanis, in press).

Interpolation

Since the coinciding values of dates from a number of chronologically different horizons are seen as evidence for radiocarbon fluctuations, resulting in impossibility to rely solely on radiocarbon dating, the horizons dated out of the anomaly are used as chronologically wide frameworks, allowing an 'interpolation' of the dates from the uncertain periods (Bojadžiev 1992, 393). The proposed sequences are conditioned by the thickness of the layers, which is used for verification of the estimated chronological ranges (Бояджиев 1986, 120; Boyadzhiev 1995, 170). Such an approach, however, is not counted reliable (Higham et al. 2008).

Owing to the absence of precise definition of the specified term, certain clarifications should be made. The 'interpolation' is intended as a shift of the late Chalcolithic set of dates, in particular, towards the younger chronological frameworks³. As indicated above, Y. Boyadzhiev suggests that as a result of the postulated anomalies the middle and late Chalcolithic dates fall within the ranges of chronologically earlier periods. Thus, they should also be examined primarily as conventional values.

This peculiarity also explains certain misconceptions regarding the views on the general chronological framework of the Chalcolithic period. Since the dates between 5500 and 5400 bp are considered typical for the final KGK VI and Varna cultures, and problematic when calibrated (Boyadzhiev 1995, 170–171; Boyadzhiev, Aslanis, in press), the graph that represents the chronological range of the Chalcolithic phases (Boyadzhiev 1995, table 4) is introduced only provisionally.

Anomalies

Because of presumed geomagnetic anomalies, especially between 4250 and 4000 BC the chronological internal separation of the Chalcolithic period in absolute dates is considered impossible also by other authors (Тодорова 1986, 38–39). However, there are no recent studies confirming or rejecting such anomalies, at least at the regional level.

In this context the correlation between the radiocarbon dating, the relative chronology and the stratigraphic sequence in multi-layered settlements, as well as the consideration of dates from problematic periods in wide ranges only, may be determined as an adequate approach for the available data. However, in addition to the great number of uncertainties associated with the observations, the results are not comparable to those obtained by the application of modern techniques for estimation of precise radiocarbon dates. The following text will examine this very approach.

B. The new AMS Varna dates

More than 100 sampling materials for AMS dating (human and animal bones) are reported as collected from the cemetery and 19 dates are published so far (see Гайдарска

³ Personal communication with Y. Boyadzhiev, who kindly clarified the commented term (January 2012).

2011, 93). Not only are the dates obtained by the Oxford laboratory (ORAU) the first AMS radiocarbon dates for the site, but also their publication introduces a methodology which, if known at all, is not widely applied in the region (especially with regard to the series of dates). The latter includes the creation of models, based on Bayesian statistics, by using the program OxCal. Its major advantage is seen in handling the dates along with their highest density probability – a statistical approach which shortens the ranges, provides for precision of dating and helps establish the presumptive duration of a phase (Bronk Ramsey 1998; Bronk Ramsey 2001).

The published new AMS Varna dates are claimed to be earlier than expected – falling within the range 4600–4550 and 4500–4400 BC (Chapman et al. 2006), which is seen as corresponding to the *Middle Copper Age* according to the quoted graph (see Boyadzhiev 1995, table 4). It is also maintained that the dates fit into the chronology accepted by the excavator I. Ivanov, namely the 4600–4200 BC time span (Higham et al. 2007, 652).

The major results of the dating project (Chapman et al. 2006, 159, 175; Higham et al. 2007, 649, 652; Higham et al. 2008, 109;) ascertain an advanced beginning of the late Copper Age in the Black sea zone by one or two centuries, as well as an earlier start of the burial practices in Varna and a variable pace for adoption of similar ceramic styles and metal objects in the different zones of the culture. The use of the cemetery is indicated to have lasted for over a century (83–178 years at 1σ), estimated as four prehistoric generations, with an average of three to four burials per annum. Spatial distribution is not detected and presumably, there are clusters of burials implemented by several communities in different areas of the cemetery, the ‘poorer’ graves defined as being later. However, the authors report that these dates refer to about 5 % of the graves. The start of the cemetery is found to be earlier, its duration - short and its demise – rapid, which is used as evidence that late Chalcolithic post-Varna materials continued to be used over 500 years (Chapman et al. 2006, 159, 177).

The site has never been dated by radiocarbon measurements before and the dates can be compared only to the general framework offered for the late Chalcolithic period in the region. The excavator I. Ivanov refers to earlier chronologies when indicating absolute ranges for the cemetery and Y. Boyadzhiev recommends consideration of the late Chalcolithic radiocarbon dates in broad ranges only. Furthermore, the offered general range refers to the cultural complex KGK VI (eastern Balkan inland area), whereas given the presumed territorial distribution of the Varna culture (the littoral zone), its specific characteristics and small number of sites, an absolute precision of such frameworks cannot be expected at this stage. This is also highlighted by the fact that there is abundant room for further progress in determining reliable synchronizations between the two cultures.

The main issue, however, relates to the further consideration of the new AMS dates. Often, they are practically disregarded as not being ‘archaeologically acceptable’ (terminology in Bowman 1995, 62), or are immediately used for modifications of the southeastern European chronology (Reingruber, Thissen 2009; Reingruber et al. 2011).

If we go back to the previous chronological frames, it should be reminded that the late Chalcolithic period was followed by a so called chronological hiatus, during which late Chalcolithic materials were still produced. According to the recent revision of the dating, the presence of post-Varna materials may also indicate production and exchange of objects in the style of Varna (or post-Varna, Higham et al. 2007, 652). On the other hand, some excavated sites revealing similar materials are interpreted as indicating continuity of life, with no evidence of sudden cultural demise or abrupt invasions (Georgieva 2003, 2005; Ivanova

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2008). Admittedly, the interpretation of the end of the culture, the eventual continuity of certain elements or styles and the reconsideration of the proposed sudden change deserve more attention. However, it is not the aim of the present paper to discuss this issue.

In accordance with the structure of the dating process, the examination of the possible factors that may influence the AMS dating results, along with clarifications of the comparisons with previously established dates, will be presented below.

Dated materials: AMS dating of bones

'A more powerful telescope needs more careful handling' (Bronk Ramsey 2008, 266) is a statement that refers to a comparison between conventional beta counting and AMS radiocarbon dating. The efficiency of the AMS is greater, but there may be certain issues related to the smaller size of the AMS samples (cf. Bronk Ramsey 2008, 258–259). Furthermore, bone is considered a material that may be problematic to date (Walker 2005, 19, 31). The radiocarbon date does not indicate directly the context (Bronk Ramsey 2009, 349; Bowman 1995, 12), it rather denotes an estimated time since death. In addition, there is a number of issues related to the preservation and the characteristics of this type of dated material.

Radiocarbon primary reservoirs and reservoir effects

Since dating is based on measurement of the carbon isotope ratios ($^{14}\text{C}/^{12}\text{C}$ and $^{13}\text{C}/^{12}\text{C}$), the ascertainment of the radiocarbon source is considered crucial and 'any uncertainty of the contribution of non-terrestrial food sources compromises our ability to get good chronological resolution' (Bronk Ramsey 2008, 259–260). Therefore, some specifics of the region and certain studies on the palaeoenvironment will be presented below.

Marine offset measurements and freshwater reservoir effects

The generated content of ^{14}C may fluctuate considerably over periods, depending mainly on cosmic rays flux and the Earth's magnetic field (Bronk Ramsey 2008, 250–251). With regard to the *oceans and seas* the problem is even more complex because of the specifics of oceanic circulation. Although there are attempts to establish the local variations of oceanic radiocarbon concentration, they are not considered sufficient for the suitable solution of the problem (Bronk Ramsey 2008, 252). With regard to the Black Sea values, currently there are few published measurements that may be related to the sea water values in regions located near Varna (sample 247 from Cogealac, Romania; 246 from Tsarevo, Bulgaria and 244 from Northern Turkey (represented in table 2 here; generated on <http://calib.qub.ac.uk/marine/>, the main address of the CHRONO Centre being <http://www.calib.org/>, see also Reimer, Reimer 2001 and). However, detailed studies are still expected.

Dating samples with 'marine component' (such as human bone from sites located in coastal regions) require special attention. Although the preindustrial correction is estimated at about 400 years, the local differences may vary considerably according to the specific features of the regions. The procedure for correction of the *marine reservoir effect* includes a number of complex conversions (Reimer, Reimer, 2001, 461), which not only involve considerable uncertainty, but also result in estimates, which are based on present-day values (see above). The possible range of the Black Sea marine reservoir effect is suggested between 380 (Higham et al. 2007, 643) and 410 years (Honch et al., in press). The Black Sea however, is a relatively enclosed body influenced by modern factors, by variable ^{14}C residence time and salinity. Furthermore, the properties of the fish environment (the surface

	MapNo	Lon	Lat	DeltaR	DeltaRErr	Locality	ReservoirAge	ReservoirErr	C14age	C14err	LabID
☐	246	28.0000	42.1700	-10	40	Black Sea	363	41	480	40	GifA 96698
☐	247	28.5000	44.5000	126	40	Black Sea	498	41	615	40	GifA 96701
☐	244	28.5800	41.5000	91	40	Istanbul, Turkey, Marmara Sea	475	41	545	40	GifA 96713

Table 2. Measurements of sea water values (sample 247 from Cogealac, Romania; 246 from Tsarevo, Bulgaria and 244 from Northern Turkey. The table is generated on <http://calib.qub.ac.uk/marine/>, the main address being <http://www.calib.org/>, see Reimer, Reimer 2001)

Табл. 2. Измервания на морска вода (проба 247 от Румъния, 246 от Царево, България и 244 от северна Турция. Таблицата е съставена чрез <http://calib.qub.ac.uk/marine/> (<http://www.calib.org/>, вж Reimer, Reimer 2001)

water) are different from those of the other sea water levels⁴. There are no special studies on the possible marine reservoir effect in the region and for that reason the AMS dating results are difficult to verify.

Another challenging aspect is the *freshwater reservoir effect*, which depends on a great number of factors, including modern conditions (Bronk Ramsey 2008, 252–253). For that reason, the attempts to apply corrections to *lake* reservoirs shall take into account the specifics of each site (Reimer, Reimer 2001, 462). A recent study of Lillie et al. (2009) involves correction of the possible freshwater reservoir in some areas along the Black Sea littoral zone. However, such studies on the river/lake or marine reservoir effects are currently not applied for Bulgarian regions.

It should be reminded, that the Chalcolithic Varna cemetery is located in the coastal area, at the lake-shore, the Varna lake being connected both to the Provadiyska River and the Devnya River (Ivanov 1988, 64–65), as well as to the sea. Many factors, among which the lake salinity levels, demonstrate the complexity of the question whether a possible reservoir effect should be more carefully considered and if so, is it marine, freshwater (either river or lake) or even more complex one.

Palaeoenvironment and sea level

Sea level changes may have certain impact on the possible reservoir effect and the water salinity. Although the major cultural changes at the end of the Chalcolithic period in the region have been explained in previous studies as a consequence of sudden climatic changes, current researches ascertain their gradual nature (Dolukhanov, Shilik 2007, 314). It is suggested that the slow-rate shoreline migrations did not have direct effect on prehistoric groups beyond the littoral zone (Dergachev, Dolukhanov 2007, 507). In the gradual Black Sea Holocene transgression – the registered Dzhemetinian stage (5000–3000 BC) – there were three major phases, at 4600, 4200, 3800 BC, which brought the sea level approximately to the present-day level or slightly above, resulting in submergence of late Chalcolithic settlements (4450–4200 cal BC), (Dergachev, Dolukhanov 2007, 493, 509; Filipova-Marinova 2007, 472).

The Black Sea Holocene transgressions were conditioned by glacio-eustasy, tectonic effects, changes in the water balance and the freshwater river discharge (Dergachev, Dolukhanov 2007, 508). The coastal lakes, such as Varna Lake, enlarged after the Chalcol-

⁴ A note made by Prof. A. Keenleyside, Trent University, personal communication (email from December 21st, 2011).

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ithic period and present estuarine-bays turned into a large embayment of the sea, reaching the mouth of the rivers Provadiyska and Devnya. At the beginning and end of that event, the natural reservoir was considerably fresher, but during the transgression maximum its salinity was close to that of the sea (Filipova-Marinova 2007, 469). A complex factor that may also influence the radiocarbon dating results is the fact that the Black Sea was a freshwater lake, which gradually filled with salty water.

Diet and fish consumption: how evident it is in the Chalcolithic?

Despite the archaeological evidence for fishing activities, in some cases marine or freshwater fish consumption is not ascertained in the measured isotope ratios. For some sites, however, $\delta^{15}\text{N}$ values between 10.5–11.8‰ and 11.4–13.0‰ show strong influence of river fish in the diet, but also – variability in consumption patterns.

The presence of freshwater reservoirs cannot be ascertained by AMS measurement of human samples only. In order to refine the proposed chronologies and evaluate the reservoir effect, fauna (including ichthyofauna) values shall be compared to the results from human bone sampling (cf. Bonsall et al. 2009, Lillie et al. 2009, 258). Such an approach, however, cannot be fully used in Varna – the excavations were in the 1980s and there were no preserved fish-bones reported. It should also be noted that in certain periods the shift in the hydrological regimes in the Black Sea region influences the reservoir effect and, at least in Ukraine, for some Chalcolithic periods 'the reservoir effect has all but dissipated', in contrast to the Neolithic (Lillie et al. 2009, 260–262).

Differences in marine-terrestrial isotope ratios: are there 'hidden' values?

Coastal populations are expected to have higher $\delta^{13}\text{C}$ collagen values. However, an issue related to the Mesolithic-Neolithic transition in North-Western Europe regards the extent to which fish consumption (evidenced by fishbone residues found in modest amounts), are (or actually are not) reflected in human bone collagen isotope values (Lee-Thorp, 2008, 936–938).

When consumed, freshwater or anadromous species 'may represent foods low in ^{13}C , rather than high, as is the case of marine fish' (Lee-Thorp, 2008, 938). The suggestion that the combined intake of small amounts of marine and freshwater fish is not reflected because they neutralize each other (Fischer et al. 2008) is not accepted, due to the high $\delta^{15}\text{N}$ of freshwater fish (Lee-Thorp, 2008). With this regard, it should be noted that anadromous fish, such as eels (Anguillidae), although presently included in the list of threatened species, lived in the Varna coastal lake up to the 1950s (Червена книга на Република България, <http://e-ecodb.bas.bg/rdb/bg/vol2/Ananguil.html>). Another anadromous fish that is becoming extinct is sturgeon (Acipenseridae), also known to be found in the Black sea coastal zones and rivers (<http://e-ecodb.bas.bg/rdb/bg/vol2/Huhuso.html>).

When considering the impact of diet on the possible chronological estimates, it should also be mentioned that, if the marine component consisted largely of shellfish, this could also lead to a large reservoir effect, but to a very small increase in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values (see Bonsall et al., 2009)⁵.

Another view relates to the uncertainties resulting from the routing models. The $\delta^{13}\text{C}$ in marine organisms correlate with salinity and the dietary end members may exhibit 'suspicious estimates of the proportion of marine protein in the diet'. Terrestrial diet, based on

5 Attention drawn by prof. C. Bonsall, whom I'm sincerely grateful.

plant consumption mainly, could reduce the value of $\delta^{13}\text{C}$ in the bone collagen and thus the dietary proportion estimates will be unreliable. In a plant dominated diet, up to 20% of the protein could come from marine sources without shifting the $\delta^{13}\text{C}$ value from -21‰ (summarized in Pollard and Heron, 2008, 363). Thus, the question about the errors related to 'minor marine components' (Hedges 2004, 35) and their probable influence on the radiocarbon date remains open.

Other isotope studies from the area

The first and yet single other dietary study from this Black Sea region is based on analysis of human and faunal remains from the cemetery of Apollonia (present-day Sozopol), dated from the 5th to 2nd century BC (Keenleyside et al. 2006). The diet is recognized as mixed – consisting of predominantly terrestrial and some marine components. Compared to herbivore ranges, the human values are enriched: the mean carbon values are 2‰ higher (between -19.5‰ and 17.8‰) and the nitrogen values are 5‰ higher (ranging between 8.5‰ and 12.2‰) than those for the fauna (Keenleyside et al. 2006, 1209). Given the year of release, coinciding with the first publication about Varna, and the chronological gap between the sites, there are still no current comments on eventual comparison between the sites. It should be noted, however, that despite the mentioned differences, the results about the two sites can be considered close.

Diet in Varna: how much is enough?

Although the consumption of freshwater and marine fish can contribute depleted ^{14}C and enriched $\delta^{15}\text{N}$ values (cf. Cook et al. 2001), the predominant diet in Varna is defined as based on C_3 terrestrial animal protein, with 'some evidence for a contribution to the diet of marine foods amongst a minority of individuals' (Higham et al. 2007, 643). The $\delta^{13}\text{C}$ human values range from -20.0 to -18.5‰ (average -19.1 or -19.3‰) and the $\delta^{15}\text{N}$ ranges from 8.7 to 11.3‰ (average 10.3 or 10.0‰). These values are higher than those registered in Durankulak (Higham et al. 2008, 102), (fig. 3). The slightly enriched carbon values (compared to humans from inland continental Europe (-20 to -21‰)) are attributed to climatic variations (Honch et al. 2006, 1497-1498). There is however, a recognized linear trend, similar to those of populations utilizing significant marine protein – nine individuals out of 55 have nitrogen values close to or greater than 11‰ (Honch et al. 2006). Although evaluated as minor in general, among these there are dated graves containing bones enriched in both C and N (№ 43). The proposed conclusion, however, was that despite their coastal location the populations did not utilize marine resources to any significant degree (Honch et al., in press, 87).

Nevertheless, it should be noted that fishing equipment, fish-bones and shells are found in a number of sites, including Durankulak (Тодорова 1986, 143), where isotopic studies of diet do not register the C- or N-values indicative of fish consumption. Furthermore, it is worth reminding that the Varna population exhibits higher isotopic values compared to those of Durankulak individuals (Honch et al., 2006).

Three pairs of terrestrial animal and human bones are compared to assess possible reservoir effect (sampled bones from grave 111, 117, 143), (Higham et al. 2007, 643). For two of them the human bones are older, which may also indicate reservoir effect. The third pair (grave 143) does not show an offset, but probably consists of two human bones (Higham et al. 2008, 101) and therefore is not considered a valid comparison here. As mentioned above, 'small reservoir offsets amongst a minority of individuals' are allowed (Higham et al. 2007, 646). Accordingly, a minority of individuals (including the well-known grave 43)

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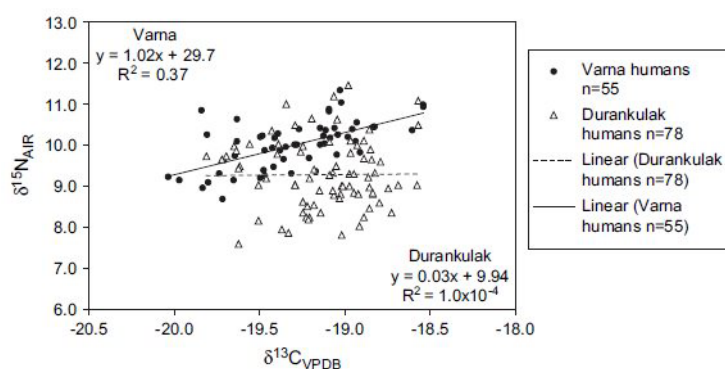


Fig. 3. Stable isotopes data (C and N) for humans from Varna and Durankulak, collagen samples (after Honch et al. 2006, fig. 3)

Обр. 3. Стойности от изследване на стабилни изотопи върху костни човешки останки (колаген) от Варна и Дуранкулак (по Honch et al. 2006, fig. 3)

that show enriched carbon and nitrogen values used marine resources in their diets (Honch et al. 2006). Indeed, apart from the ambiguous human-human pair, the two pairs indicate depleted $\delta^{13}\text{C}$ values by one per mil (compared to animal bones), and for the two reliable human-animal pairs the nitrogen isotopes are not measured for the animal bones (table 3). Yet later (Higham et al. 2008), the probability of a substantial reservoir effect is considered to be low, and the human sample, older by 200 years compared to the animal bone, is explained as resulting from the low collagen content (Higham et al. 2007, 464).

Important is the fact that certain individuals, including some from the dated graves, may have utilized marine resources. Apart from the measurement of C and N in different bones, further differentiation between terrestrial and marine diet could possibly be suggested after measurement of sulphur (Privat et al., 2007) or stable isotope analysis of specific amino acids (Bronk Ramsey 2008, 261).

Application of amino acid stable isotope analysis for dietary reconstruction (Honch, 2008) indicates that – with regard to carbon – there are ‘few to no amino acid $\delta^{13}\text{C}$ differences between the selected individuals’, considered by the author as an expected result, given the little variation of the bulk $\delta^{13}\text{C}$ values, i.e. further amino-acid differences were not expected (Honch, 2008, 100, 305)⁶.

It should be mentioned that issues related to the samples are considered in the quoted studies about the Varna dates. However, at this stage and according to the data published so far, the question of a possible reservoir effect does not appear to be completely resolved, because of the lack of a basis for direct comparisons in the region (including inland contemporaneous sites), and also due to the specifics of the cemetery, the number of sampled pairs of human-animal bones and the registered marine component in the diet of some of the dated individuals. Additional observations will be presented below.

Diagenesis and sediment contamination in the region

Radiocarbon data may be influenced by the changes occurring after burial, related to specific modifications, uptakes, elements exchange or leaching. Collagen content and histological index indicate the diagenesis effects, whereas porosity and crystallinity reflect the response of bone to its environment (Hedges 2002, 319–320). Because of the possible influence of the general context of the samples, ‘the ecological setting of an archaeological sample’ should be considered along with its taphonomic and geochemical characteristics (Hedges 2001, 7). The incorporation of earlier carbon (including petrochemicals), which makes samples appear older (Buck et al. 1996, 217), provokes a reference also to the present-

6 I thank the author who gave his permission to quote the unpublished DPhil thesis (Honch 2008).

Burial no.	OxA no.	Bone	Radiocarbon				Pretreat.			
			age BP	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	CN	Wt% coll	yld (mg)	% carbon	
111	13865	Human	5855 ± 34	-18.3	11.3	3.2	8.2	58.9	43.8	
111	13846	Animal	5757 ± 34	-19.4	n.d.	3.2	2.4	16.5	42.8	
117	13848	Human	5766 ± 36	-19.0	10.2	3.2	2.7	18.6	42.4	
117	13811	Animal	5530 ± 36	-20.2	n.d.	3.3	0.5	3.2	41.8	
143	13689	Human	5690 ± 32	-19.7	9.7	3.2	1.0	6.5	43.0	
143	13690	Animal	5700 ± 30	-19.7	10.1	3.2	2.6	17.9	43.1	

Table 3. Dated pairs of human/animal bones (after Higham et al. 2007, table 3)

Табл. 3. Сравнение на стойности на датирани кости от животни и хора (по Higham et al. 2007, table 3)

day contamination of the sediments around Varna. Its bay is artificially linked by two canals to the Varna Lake (Trayanova et al. 2011, fig. 1) and *water* eutrophication and high levels of pollution of the lake are acknowledged as considerable issues (Недева 2007, 427, 433). The two major factors for these conditions are the many years the lake has been used for shipping of freights and the great number of 'pollution sources'. The chemical, cement plant and the steel works near the lake (Simeonov et al. 2000, 1414ff.) have resulted in the concentration of heavy metals, biphenyls, pesticides, phenols and petroleum hydrocarbons also in the *sediments* (Shtereva et al. 2004). Although there are strict laboratory protocols for sample preparation and ultrafiltration (cf. Brock et al. 2010), aimed at the removal of contamination, the samples from the Varna cemetery do not belong to favourable contexts that consist of clean and non-aggressive soils.

Stratigraphy, disturbed contexts and materials preservation

With regard to stratigraphy, later researches (Slavchev, Boyadzhiev 2011) suggest a complete sequence of six registered layers in the cemetery. Nevertheless, such sequence is not established over the entire burial area. The horizontal stratigraphy does not facilitate the determination of the chronological position of the graves and many graves are described as disturbed (table 4). Often the fill of the graves has the same characteristics as the surrounding soil, thus making it impossible to mark the pit outlines (Slavchev, Boyadzhiev 2011, 75, 76–92). It is known that root penetration (Bronk Ramsey 2008, 256) may affect the quality of sampled material and certain disturbances of that nature are recorded for some of the dated graves (N 10 and N 94). Generally, the bones are poorly preserved – the highly acidic clay has resulted in highly damaged, if preserved at all, pelvis and thinner bones. Furthermore, according to the cited authors, in some of the graves the documented bones are identified as belonging to more than one buried individual (Slavchev, Boyadzhiev 2011, 76; Higham et al. 2007, 643).

Interpretation: models and statistics

The interpretation of the dates from Varna is based on the application of the INTCAL 98 and also the INTCAL 04 calibration curves, and OxCal 3.6 (Higham et al. 2007, 99), OxCal 3.10 and OxCal 4.0.1 versions of the computer program (Higham et al. 2007, 643; Higham et al. 2008, 99, 102).

It should be noted that the applied models and statistics are often questioned by the supporters of the relative chronology – especially when the Chalcolithic period in the region

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Later Chalcolithic graves disturbed/disturbing		Early Bronze Age structures	Antiquity structures	Agriculture activities	Recent building activities	During excavation	Combination of factors
18	19	33	262	184	1	163	27
28	28a	64	77	193	9	223	50
29	29a	138		197	10	285	94
47a	47	148		198	17	289	103
58	58a	178		202	21		289
61	62	20		203	22		
63a	63	27		206	62		
67a	67	212		216	63		
79	80			221	95		
102a	102			229a	104		
139a	139			248	106		
166	166a			250	118		
174a	174			251	123		
222a	222			257	130		
226	226a			265	133		
229	229a			278	169		
				285	270		
				291	289		
				292	290		
				258?	295		
				44	297		

Table 4. Varna graves defined as disturbed (see Slavchev, Boyadzhiev 2011, 76-92), some of which (red-shaded cells) were sampled for AMS dating (see Higham et al. 2007)

Табл. 4. Гробовете от некропола при Варна определени като нарушени (вж Slavchev, Boyadzhiev 2011, 76-92), от които са взети проби за датиране (номера, оцветени в червено) (вж Higham et al. 2007)

is considered as a time of atmospheric anomalies caused by natural events (Boyadzhiev, Aslanis, in press). Still, if we intend to use radiocarbon dates, along with their uncertainty ranges, we should also consider the main tools for placing the estimated series within certain frameworks.

Bayesian model

A positive example of the application of statistics relates to the standard deviations of the radiocarbon values (Thomas 1978, 232). Although models provide 'simplified view' based on limited sample of information, they may be useful and not 'importantly wrong' (Bayliss et al. 2007, 6-7, 24). What is crucial is that uncalibrated dates have a Gaussian distribution and when calibrated they lose the symmetrical connection between the central value and the error values – entering irregular probability distribution (Pollard 2009, 154). Hence, classical statistics cannot be applied and dates can be useful only when statistical methods are employed for their calibration (Bronk Ramsey 2008, 264; Bronk Ramsey 2009, 1).

This statistical approach is based on a theorem elaborated by Thomas Bayes in 1763 (Buck 2001). It allows the information available before the research to be combined with the results of the research, which facilitates the recognition of the most probable values for the

General explanation	Notions	¹⁴ C dating related explanation	Symbols	Process
New data collected about a problem	STANDARDIZED LIKELIHOOD	Scientific dating evidence - radiocarbon dates (calendar date)	p(y t)	Measurements
Existing knowledge about a problem	PRIOR BELIEFS	Relative dating evidence – stratigraphic relationships between contexts containing samples or typology (relative date)	p(t)	Defined model
New understanding of the problem (incorporates existing and new data)	POSTERIOR BELIEFS	Quantitative estimates of dates of events/ posterior density estimates (probability distributions)	p(t y)	Posterior probabilities calculation

$P(t|y)$ [the posterior probability] is proportional to $p(y|t)$ [the likelihood] $p(t)$ [the prior].

Table 5. Application of the Bayesian theorem in radiocarbon dating

(based on Buck et al. 1996, 203, 217; Buck 2001; Bayliss et al. 2007; Bronk Ramsey 2009)

Табл. 5. Приложение на теоремата на Бейс за целите на радиовъглеродното датироване (таблица съставена по данни от Buck et al. 1996, 203, 217; Buck 2001; Bayliss et al. 2007; Bronk Ramsey 2009)

consistent interpretation of the new complex information. The key concept – probability – is interrelated with uncertainty and subjectivity, hence the theorem is used as a basis for creation of a probabilistic framework for the interpretations. This also results in transformation of the present posterior data into future prior information (Buck 2001, 695–698; Bayliss et al. 2007, 4).

With regard to chronology and radiocarbon dating, Bayesian statistics combine the newly obtained radiocarbon data with the information from the calibration curve (Bronk Ramsey 2009, 337). A mathematical model applied in the statistical analysis transforms the chronology into ‘events’, or ‘single points on continuous timescale’ that help establish both the dates and the intervals between them (Bronk Ramsey 2009, 338). The application of the theorem in radiocarbon dating is represented in table 5 (based on Buck et al. 1996, 203, 217; Buck 2001; Bayliss et al. 2007; Bronk Ramsey 2009), where:

$P(t|y)$ [the posterior probability] is proportional to $p(y|t)$ [the likelihood] $p(t)$ [the prior].

Importance of the archaeological data

The distribution *noise* is also included in the model under consideration. The *prior* information (radiocarbon dates) is framed according to the stratigraphic sequence (the context layers of the samples). The incorporation of the stratigraphic information into the calibration and the model (the date from the lower layer expected to be earlier) considerably narrows the limits of the posterior date distribution ranges. ‘Problematic pairs of dates’ become outliers and are excluded from the analysis, which reduces the distribution ranges and raises the percentage of probability of the posterior chronological frames (Buck 2001, 698). The Bayesian model, however, offers accurate results only when the important prior data (the archaeological information) is correct (Bayliss et al. 2007, 11, 14, 22), and is aimed at obtaining reliable data from more sources (Pollard 2009, 152).

The OxCal model

In a very broad principle, the indicated above may be considered as somewhat corresponding to the logic followed by Y. Boyadzhiev (see part II A). Completely incomparable, however, is the quality processing of series of dates with high probability density, as well as

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the possibility of verifying the models generated. The program OxCal calculates probability distributions according to the prior information by repeatedly sampling each distribution, and thus the combinations of dates produce a narrow-range 'posterior density estimate' (Bayliss et al. 2007, 6). The application of two statistics – the index of agreement (posterior-prior distribution agreement) and convergence (speed of the MCMC sampler) – is further aided by sensitivity analysis and simulation (Bayliss et al. 2007, 6–7). However, in spite of the possibility of dividing the prior information into formative and informative, general problems may arise with 1) the model, 2) the measurement, or 3) the MCMC analysis itself (Bronk Ramsey 2009, 353–358).

Interpretation of the Varna AMS dates

The archaeological materials from the cemetery near Varna are not seen as lagging behind those registered in the settlements; just the opposite – in this case the burial inventory is the one that is considered as better representing rapid changes (Slavchev 2009, 115–116). The site was dated by the terrain researcher to the 'second half of the Chalcolithic period', accepted as correspondent to the Russe-Kodzhadermen-Gumelnița-Karanovo VI complex (Ivanov 1980, 28).

Later studies recognize that the youngest age-range proposed for the Varna II-III culture (4450/4400–4250/4150 cal BC) is found to be based on unreliable samples (Boyadzhiev 2002). The frequently quoted chronological scheme (Boyadzhiev 1995, 179, table 4) actually indicates broad ranges and there is a continuing tendency to compare bp values (Boyadzhiev, Aslanis, in press). The dates presented by Y. Boyadzhiev as typical for the final stage of KGK VI and Varna culture are set between 5500 and 5400 bp (Boyadzhiev 1995, 170).

The OxCal model, on the other hand, indicates a *terminus post quem* at 4640 BC and end of the cemetery at c. 4440 cal BC. The modelling of other sites also results in recognition of earlier dates, but these settlements are accepted as having characteristics that are closer to KGK VI (Honch et al. in press, 78–81, 95).

The archaeological information

The comparison with material culture types from other sites is essential, but in the case of the unique Varna cemetery may also be quite problematic. Furthermore, some vessels that belong to the dated Varna graves have no characteristics that are distinctive for a specific phase⁷. It should be reminded that the complete publication of the cemetery is still expected; hence, once it is released, the detailed typological observations will possibly provoke further examination of the chronological aspects and the dating results. Although the region is described as open, having no geographical barriers, presently there is no other site that has similar characteristics (cf. Lichter 2008). Besides that, the specifics of the identified culture need to be detailed and the number and the type of sites included in the Varna 'cultural range' need to be assessed.

AMS dates from other Chalcolithic sites

There are also other AMS dating results from the region that had not been analyzed in details. Some of them fit in the previously established ranges. An end-date of oak from the late Chalcolithic *Sozopol* (Black Sea coast) results in 4140 BC±19 (cal), (Kuniholm et al.

⁷ Owing to both the word limit of the essay and the present state of the publications about Varna, certain aspects of the problem cannot be examined in details here.

2007, 487) and late Chalcolithic dates from *Djadovo* (Upper Thrace) are placed in the ranges between 4500 and 4300 cal BC (2σ), (Kamuro 2011). Admittedly, here it would be impossible to correlate various sites that are otherwise defined as containing Chalcolithic layers. A further study with more focus on the variable typological and regional specifics is therefore suggested.

On the other hand, other values that are closer to the Varna AMS ranges include the dates from *Pietrele* (Romania, along the Danube River) (Reingruber et al., 2011, 119–123), the range of which is set between 4400 and 4250 BC, in accumulations of 3 to 4m. Since life in this settlement mound is claimed to have ceased after 4250 cal BC, the end of Gumelnița culture is estimated as being earlier – in 4300/4250 cal BC.

Yet other late Chalcolithic dates from *Drama* (eastern Upper Thrace) (Gleser 2011) are reported to tend towards the middle of the V millennium. The sampled animal bones, however, may be problematic and, furthermore, Kraranovo V and the subsequent phase Karanovo VI are not distinguished stratigraphically at the examined site.

As stated above, comparisons cannot be made on the basis of gained values only; they should also be examined in line with the specifics of the material culture – which may be a difficult task given their characteristics in the geographic and cultural areas under consideration.

III. Discussion

Among the other factors, the main methodological approaches for processing absolute dates in the region contrast radiocarbon dates to material culture characteristics; the application of statistics to existing observations on stratigraphic sequences; and the demand for probabilistic methods to the failure to apply them on account of suggested natural phenomena effects.

The otherwise acknowledged imperative use of calibrated values is neglected by some researchers from the focal region because of the discrepancies in calibration curves. For that reason, there is a tendency for application of uncalibrated values as reference points, along with the so-called interpolation (see part II A).

The new AMS dates allow for evaluation of the previous researches, but nevertheless these should be carefully considered before being immediately implemented in building new chronologies. Specifics related to the sampled materials, the methodology and the reliability of the results (see section II B) can affect the use of the dates from certain sites as basis for further chronological modifications.

The site and sampled materials

The new AMS dates for Varna result from the most advanced techniques (Bronk Ramsey et al. 2004), implemented by leading experts in the field (Higham et al. 2007). Certain issues, however, are related to the samples and the region and furthermore – the necropolis under examination cannot be considered as the best source of sampling materials when compared to settlement sites with reliable stratigraphic sequences.

Verification of the results according to the site information is impossible at this stage – the sampled graves contain typologically different finds and no horizontal stratigraphy in the flat cemetery can help distinguish chronologically between the dated burials.

The excavations are from the 1980s, a quarter of the site is still not explored, and the storage conditions of the bones are unknown. The bones are considerably damaged due to

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highly acidic soils (a major issue according to the Waterbolk criteria, see Pettitt et al. 2003) and thus the selection of bones depends on the extent of their preservation. Another negative statement relates to the terrain, which has been included in intensive agricultural and building activities.

The site is unique, recognized as representing a specific coastal phenomenon that is not registered in other cemeteries of this size or 'importance'. Therefore it may be difficult to make comparisons to other sites or materials. The AMS dating results are the first radiocarbon measurements applied for the cemetery – they cannot be compared to previous results, and besides, the sampled material may also cause certain problems.

The measurement of bone samples from coastal regions is related to many factors that may result in ambiguities – from diagenesis to variations of the possible reservoir effect (both freshwater and marine, given the specifics of this coastal lake). In spite of the lack of firm indications of a reservoir effect, the question cannot be considered resolved – at this stage the measured human-animal pairs are only two, no fish-bones are preserved to be examined, there are individuals with marine diet signal among the dated graves, and many ambiguities are related to the question of how much of the consumed marine protein is reflected in bone collagen. The latter, along with the possibility for freshwater reservoir effect, may have a considerable influence on the chronological interpretation. Furthermore, at this stage the values cannot be compared to those from contemporaneous sites in the region, especially inland sites, representing populations whose diet consisted of mainly terrestrial food. Some of the collected samples are from burial contexts that are disturbed, there are graves containing bones from more than one individual and in general – there are many issues related to high contamination in the region. With regard to the dietary study, possible complications that may be carried by factors such as age and growth, routing and turnover, various climate or stress effects are yet to be clarified along with the probable reservoir effects.

With regard to certain issues with AMS dated animal bones that differ from the expected results or from those obtained by charcoal dating, it is worth mentioning Göbekli Tepe (Dietrich 2011) – a chronologically different (Neolithic) site, which however, indicates certain methodological problems. Along with the insufficient collagen, the AMS dated bone there tends to indicate years, which are systematically younger compared to the charcoal results.

Methodology

Among the major characteristics of dating results is their relativity, which necessitates the application of statistical models and calibration programs. It cannot be predicted whether future advanced techniques will confirm the current AMS dating. Yet, at the present stage, the factors that may hamper the reliability of these results should be eliminated to the greatest possible extent.

As there aren't conventional dates from the cemetery near Varna, the difference set between the previous chronological frameworks for the Chalcolithic period and the new AMS range to a great extent lies also in the converse general approaches. The regional conventional dating is based mainly on measurements of charcoal and seeds found in settlement mounds. Such dates were also processed according to assumed relation between the type of the sample and the possible start- or end-date of a horizon (which cannot necessarily be established as a rule). Generally, the review of the methodology indicates possible issues with previous approaches and beta counting radiocarbon dating (related to the old-wood

effect, the determination of 'correct' dates, their distribution in horizons, applied calibration curves and interpolations). The differentiation between horizons at certain sites, some conditional chronological frameworks and the lack of techniques for verification of these approaches necessitate precisions and represent an important issue for future research.

Even when the possible complications with the applied methodology are all considered, and the defined chronological ranges are used as very broad reference points, there also may be problems associated with synchronizations based on stratigraphy and unknown actual durability of the cultural phenomena – especially with regard to the different accumulation rates in various sites (see Reingruber et al. 2011).

Furthermore, there is still no evidence whether the suggested Chalcolithic variations in the radiocarbon concentration are actually caused by natural phenomena. Some regional variations reflecting local difference in $^{14}\text{CO}_2$ uptake (although on a different scale) are also indicated in chronologically later phases of Gordion (the 'Gordion Young' set of dates, indicating regional radiocarbon offset during the 8th century [Manning et al. 2001, 2533–2534]) in Anatolia (which may be considered as not being too far away from Thrace). These may have been caused not only by marked atmospheric cooling and reduced solar input, but also by volcano eruption with great regional impact and short-term climate effect (Manning et al. 2001). However, the quoted example refers to later periods and to application of combined dating techniques (dendrochronology and wiggle-matching), which are not applied in Bulgarian regions.

On the other hand, if there is no correspondence between the new AMS dates and the material cultural characteristics, this cannot be explained simply by possible different development pace of the cultural phenomena registered in this unique site. The ascertained chronological ranges and the time-span of the cemetery containing 310 graves are based on 19 presently published samples from contexts located in different zones of the site. This also relates to the estimated average of 4 burials per year – a suggestion which is not accepted here as generally valid for the whole site. The possible use of the cemetery by several communities, the presence of warrior graves or graves dedicated to people who died elsewhere, renders the interpretation also of the isotope ratio studies on intra- or interpopulation diet even more complex.

The differentiation between earlier lavish and later poor graves at this stage may also be provisional – it depends on the data combined in the model and, probably, on the spatial distribution of the sampled materials. The applied model that includes all graves belonging to one phase is the most appropriate, but more combinations may also be possible in order to establish clusters of burials across the cemetery area.

Certainly, the specifics of the two approaches may produce different results when suggesting chronological frameworks, especially in the case of Varna, where the AMS dates for human bones from a cemetery and the conventional dates from settlements in the broader region cannot be directly compared. The main issue at present, however, is how the results can be employed for further precision in dating or correction of chronologies or, in other words, has the collection of quality data reached a level that would allow us to modify the chronological frameworks. Additionally, the remainder of the new AMS dates from the region continue to be processed by various calibration curves and programmes, in accordance with the respective laboratory practices (in Germany, France, Japan), and furthermore the relations between the sites, in terms of chronological or cultural characteristics, are still not absolutely clear.

Results: effect and prospects

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The new AMS results are not applied in local studies, whereas other researches consider the dating of Varna and Pietrele as a reason to rethink the beginning and the end of the entire culture – making the late Chalcolithic period 200-250 years earlier. Since it is considered that life in Pietrele has ceased in 4250 BC, such modification would allow for the Varna date (4550 BC) to be incorporated within the proposed framework (Reingruber, Thissen 2009, 763, 765; Reingruber et al. 2011, 119–123). It should be noted however, that the Pietrele chronological models are still preliminary – the excavations are on-going, the base of the cultural deposits has not been reached yet, and there are some complications regarding the characteristics of the pottery (see Reingruber 2010). Compared to the Varna culture (seen as coeval to the second part of Gumelnița), the Varna cemetery dates are considered to be 200 years older. The authors quoted above do not take into account even a minimal reservoir effect. Furthermore, no explanation is offered for the overlap registered between Neolithic and Chalcolithic dates, which reminds some of the observations of Y. Boyadzhiev. Finally, a revision should not be based on results for two sites only – a settlement mound exceeding 5 metres from the inland Gumelnița culture and an exceptional cemetery from the coastal 'Varna culture' that may differ even from the nearest sites in the region. The characteristics that reflect the cultural attribution of these sites cannot be considered fully comparable in terms of stratigraphy, materials and location.

The fact that there is no later horizon registered in Pietrele may not be a sufficient indication of the end of the entire Gumelnița culture and the KGK VI complex spreading over the eastern Balkans in general. New data about life in the coastal zone, after the abandonment of the settlements around 4500 cal BC, demonstrate artefacts characteristic of the style of KGK VI – Kableskovo, Kiten, Sozopol (Георгиева 2003; 2005; Ivanova 2008). There are no absolute dates for these settlements yet, although they can shed light on the problem of the chronological position of the Varna culture and the later, 'post Chalcolithic' processes.

The cemetery of Varna is still unpublished and the typology of the pottery or the metal finds has still not been examined in great detail in a complex study. The entire set of 100 materials sampled for AMS dating so far, is not published either. Thus, chronological modifications should be reconsidered after the results are completely published, especially with regard to the specifics of the site and the suggested culture.

Conclusion

The AMS Varna dates may *appear* earlier, because of methodological differences between the accepted schemes and the new approach (i.e. between 'interpolated' frameworks based on conventional values and calibrated, statistically processed dates). They may also appear somewhat earlier, because of factors such as reservoir effects – a possible issue, which is not considered as convincingly solved at this stage, bearing in mind the available number of verifications, the location of the site and the various factors that may influence the results about chronology and diet. With this regard, apart from other sites that could possibly provide reliable results, some artefacts or tools made of bone, found in the cemetery, could also be dated.

On the other hand, the assumption about local anomalies should also be based on additional and more complex data, and a dialogue should be initiated between the followers of the different approaches. Therefore, further study with more focus on the indicated aspects is suggested.

Before the final conclusions are made, additional research needs to be undertaken

also to confirm whether the AMS dates are actually earlier. Thus, the verification of the cemetery dating would help ascertain the reliability of both the previous schemes and the new approaches.

The immediate resolution of the complex issues related to the chronology of the Chalcolithic period in the eastern Balkans should not be the purpose of the new AMS dates from this specific site. Considered cautiously, they are invaluable indicators of the revisions required for the achievement of a new scientific level of prehistoric research in the region. Their major effect will emerge when all the available archaeological data are considered in terms of precision of methodologies and studies on the possible regional variations.

The need for a dating strategy is obvious: in this region of the eastern Balkans single samples from distant sites with different characteristics cannot be considered sufficient at this stage. A possible solution is the collection of samples from on-going excavations – consecutive layers in newly excavated multi-layered sites, where the complete early-late Chalcolithic development can be established. Another option could be the examination of previously excavated and dated settlement mounds, the remaining sectors of which are still to be explored, and to compare dating values from the corresponding strata. Dating of recently investigated coastal late Chalcolithic settlements, where Varna style objects are discovered, or wiggle-match dating of sites from the coastal area, are yet other options (for wiggle-matching dated sites in the region see Weninger et al. 2010). The latter may also establish eventual regional specifics or volcanic activities, resulting in narrow confidence intervals (Baillie 1982; Blaauw et al. 2003, 1499).

Simply new or more dates are not necessary, rather the need is for dates from reliable materials, distinct contexts and precise stratigraphic sequences related also to typologically diagnostic finds. Currently, it may be appropriate to consider the Varna dates from another perspective – not as means for immediate modifications of chronologies, but as important data relating to the characteristics and development of this specific site.

Given the current tripartite general periodizations (early, middle and late phases), the complete set of dates, along with recent AMS dates from the nearest sites, will prove invaluable for the precision of the local chronology. Consequently, they may allow reconsideration of the cultural interrelations within the applied major cultural ‘frameworks’, such as the ‘cultural complexes’ that cover the entire eastern Balkans. The latter, however, would be possible when complex data from a number of sources are all put together.

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По-ранни ли са новите AMS дати за варненския халколитен некропол?

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(резюме)

Въпросът е поставен поради наличните сравнения между предходни хронологически рамки и по-късни AMS резултати. Като конкретен пример е разгледан халколитният некропол до Варна, според чието датироване някои автори предлагат промени в хронологията за източната част от Балканите. Новите дати за некропола представляват AMS резултати от изследване на костен материал, които са сравнени с хронологически схеми, основани на „конвенционалното“ изследване на дървесни и растителни видове: това са и двата основни подхода, разгледани в статията. Вниманието е насочено именно към проблемите по определянето на времеви обхват въз основа на конвенционални и AMS радиовъглеродни дати, а не върху сравняването на единични абсолютни стойности за обекти от района.

Тъй като радиовъглеродното датироване е сложен процес, зависещ от много фактори, тук подробно са разгледани условията, които обуславят качеството на резултатите. Съобразно основните компоненти на този процес, работата се състои от три дяла. Те включват характеристики на обекта (I), специфики на радиовъглеродното датироване (II) и дискусия (III). Основната част от изложението разглежда възприети подходи за анализ по „конвенционалния метод“ (II A) и надеждността на интерпретацията на резултати от AMS датироване (II B).

Във *въведението* са посочени целите на работата, уточнени са и основните въпроси, според които е организирана информацията. В *първата част* (I) накратко е представен обектът – неговото значение и възгледите за предполагаемата му хронологическа позиция. Отбелязани са географските особености на района и местоположението на некропола. Наред с основни археологически характеристики са засегнати въпроси относно култура Варна (обр.1).

Във *втората част*, която е съществена за работата, са разгледани накратко установени подходи за анализ на радиовъглеродни дати от България (II A), както и принципи за използване на резултати от AMS датироване (II B). Коментирани са важни фактори, които влияят на качеството на резултатите, а също и данни, които до момента не са разглеждани критично. Посочени са особености, свързани с характеристиката на датированите материали. Поради обема на работата някои фактори, необходими за установяването на точни резултати, са само споменати.

По отношение на резултатите от „конвенционалното“ датироване (II A) са посочени някои възприети от специалисти периоди на колебания на концентрацията на въглерод в атмосферата. Те са предложени от цитираните автори за времето на почти всички халколитни периоди (средата и втората половина на ранния халколит, началото на средния халколит и неговата втора половина, и началото на късния халколит). Отбелязано е, че възгледът за наличие на аномалии и средносрочни вариации е в основата на досегашната работа с ^{14}C дати, получени вследствие на анализирани растителни видове. Поради тези аномалии досегашните хронологически граници са предложени условно и са съпроводени с редица уточнения. Приложен е и конкретен

Are the 'new' AMS Varna dates older?

пример за стойностите на датите от селищни могили и техните вариации (табл. 1). Коментирани са фактори, свързани предимно с дървения материал, които могат да повлияят на резултатите от пробите. Също така е обърнато внимание на характеристиките на събирани за датиране материали. Проблеми относно прилагането на калибрация и използвани калибрационни криви също са посочени като аспекти, които заслужават внимание. Отбелязани са особености, свързани с т.нар. интерполация, поради която все още има някои неясноти между привържениците на коментираните два различни подхода. Посочено е, че за да бъдат безспорно доказани предположените аномалии, са необходими допълнителни данни, които биха спомогнали за изясняване на позицията относно калибрираните стойности.

Във връзка с AMS датирането (II B) са отбелязани както основни резултати относно датирането на некропола, така и редица проблеми. Те са обусловени от прилагането на новата техника, спецификите на костта като материал за датиране и условности, свързани с начина на живот и хранене на населението. Специално внимание е обърнато на резервоарния ефект, който може да се отрази в нереални стойности за времето, отминало от смъртта на индивида. Варненският некропол е разгледан дори като по-сложен пример, тъй като е разположен в близост до Черно море, но същевременно – и до сладководни източници (обр. 2). Когато се вземат предвид също така особености на палеосредата, морското равнище, солеността на водите и възможността да са използвани морски храни, речни риби или такива, които обитават и сладки, и солени водни пространства, се изяснява необходимостта от специални изследвания, които да подкрепят или отхвърлят влиянието на този фактор. Допълнителни коментари са включени също по въпроса за установяването и силата на подобен сигнал при различни обстоятелства и в различно време. Посочен е проблемът за степента на проученост на района (от гледна точка на изследването на палеодietetата) и липсата на 'репери', указващи очакваните местни стойности, характерни за преобладаващи типове хранене. Споменати са и фактори като екологичната обстановка в района, агресивността на почвите и детайли от стратиграфските наблюдения (табл. 4). Разглеждането на въпроса е придружено с представяне на основните статистически подходи, залегнали в обработването на AMS данни. Програмата, използвана за 'серията' от дати включва ползване на стойностите според границите на тяхната най-голяма вероятност. В съвременните изследвания този подход е установен като норма за постигане на достоверни резултати, разгледани в рамките на общите хронологически граници за даден обект, период или дори съоръжение. Обяснено е приложението на теоремата, (която е в основата на метода), за археологически цели и конкретно – за радиовъглеродно датиране (табл. 5). Подчергано е значението на качеството на археологическите данни, което пряко влияе и върху резултатите от прилагането на статистически обработени серии от дати. Обърнато е внимание на модела, използван в конкретния случай, както и на основните статистически подходи, чрез които се извършва проверка на изработените модели. Допълнително са споменати и проблеми, свързани с ключовите компоненти при подобна практика. Накратко са посочени AMS дати от други халколитни обекти, които обаче на този етап не могат да спомогнат за изясняване на въпроса.

В *третата част* (III) са изброени проблемите свързани с хронологията на некропола. Според основните въпроси, зададени във въведението, те касаят: (а) обекта и изследваните материали, (б) подходите за извеждане на резултати и (в) интерпретацията на данните. Отбелязани са някои несъответствия при сравнението между нови-

те резултати и по-рано определените, условни хронологически граници. Подчертани са двете основни отличаващи се тенденции: 1) становището за локална аномалия на Балканския полуостров, поради която радиовъглеродните дати за някои периоди не могат да се използват като достоверен източник, и 2) задължителното калибриране и приложение на статистически модели за получаване на съгласувани помежду си стойности.

Според изложените наблюдения, в третата част от работата е посочено, че използването на данните при приложението и на двата подхода се нуждае от прецизиране или ревизия. Новите дати са определени като безспорно важен и необходим етап от работата по определяне на хронологията на разглеждания период. Подчертани са обаче условности, които *на този етап* възпрепятстват безкритичното приемане на 19-те публикувани до момента AMS дати от Варна като стабилна основа за цялостно реорганизиране на хронологически схеми. За да бъдат утвърдени като сигурни дати, представлящи възможно най-точно времеви отрязък, през който е използван разглежданият некропол, са необходими допълнителни данни. Те включват публикуване на всички дати, получени по този метод; представяне на повече сравнения между датирани животински и човешки кости; и провеждане на допълнителни изследвания, които да покажат дали резултатите не са повлияни от резервоарен ефект. От друга страна, предстоящата пълна публикация на некропола би позволила конкретното разглеждане на типовете находки спрямо предложеното датиране на някои от контекстите. То би спомогнало за изясняване на характеристиките на културата в района и връзките със съседните културни ареали.

Не на последно място е подчертана и необходимостта да се представят повече данни относно предположените аномалии, които да изяснят въпроса с локалното разглеждане на датите от източната част на Балканите. Това би позволило евентуалното приемане на предложените по-рано времеви рамки или убедителното преразглеждане на досегашната хронология. От изключителна важност за анализа на резултатите е определен комплексният подход и съчетаването на методи за датиране.

В *заключение* е препоръчано развитието на стратегия за датиране, което да бъде основано на изследване на качествени проби от обекти с надеждна стратиграфия, повече напластявания и детайлни наблюдения върху характеристиките на материалната култура.