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ABSOLUTE DATING OF COPPER AND EARLY BRONZE AGE LEVELS AT THE EPONYMOUS ARCHAEOLOGICAL SITE BUBANJ (SOUTHEASTERN SERBIA)

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ABSTRACT. This paper reports the first radiocarbon (^{14}C) dates obtained for the Eneolithic/Bronze Age site of Bubanj, Serbia. Despite featuring prominently in the existing typo-chronological schemes for southeastern Europe, the history of research and recent large-scale destruction of the site had prevented so far the acquisition of samples from secure archaeological contexts. We fill this documentary gap by presenting 10 new ^{14}C dates, covering the late 5th, 4th, and 3rd millennia cal BC. These dates are compared to the existing documentation from the literature, in order to assess the placement of Bubanj within its wider archaeological context.

KEYWORDS: AMS dating, Bayesian modeling, Copper Age, radiocarbon AMS dating, settlement.

INTRODUCTION

The radiocarbon (^{14}C) record for Later Prehistoric Europe is arguably one of the richest, if not the richest, across the world, both in terms of quantity of dates and density of geographical coverage. That being said, the state of affairs remains far from ideal as numerous documentary gaps persist, generally related to the history of local research and corresponding delays and logistical limits in adopting and using the ^{14}C technique. Without much surprise, perhaps, one of these gaps is centered around the central Balkans, corresponding to most of modern-day Serbia south of the Sava and Danube rivers. While the record for the Mesolithic and Neolithic periods is good, thanks to the presence of famous sites that have attracted continuous scientific attention (e.g. the Danube Gorges and the site of Vinča; see recently Bonsall et al. 2015; Tasić et al. 2016), later periods are less well-covered. This situation is particularly unfortunate as this area lies at the crossroads of many natural communication routes connecting central Europe with the Balkan peninsula and, beyond, the Aegean and the Adriatic seas. The natural corridors include numerous large river valleys (Velika Morava, Južna Morava, Nišava rivers), and seem to have been preferentially settled during later prehistory.

The site of Bubanj, which is the focus of this paper, lies at the heart of one of these corridors, more precisely at the confluence of the Nišava and Južna Morava rivers, approximatively 5 km to the west of the modern city of Niš (Figure 1). The first excavations were conducted during the 1930s and provided important results quickly published by the Austrian Academy of Sciences in Vienna (Orsich de Slavetić 1940). This prehistoric site then covered an extensive surface estimated to approximately 3.5 ha, stretching over three main areas (western, central, and eastern), and appeared to have been almost continously occupied from the Neolithic to the Bronze Age (e.g. existence of stratigraphic profiles up to 3 m high). Further excavations took place during the 1950s, mostly centered upon the central and western areas (Garašanin 1958). Following this phase of fieldwork, sequence and material culture from Bubanj as an eponymous site for several Eneolithic and Bronze Age archaeological cultures (Garašanin 1958). It is noteworthy that no samples were then taken for ^{14}C analysis, admittedly still in its early stages.

The first cultural group named after the site is the Bubanj-Hum I group, which corresponds to the Early Eneolithic in the local terminology. This group belongs to the larger Bubanj-Salcuţa-Krivodol cultural complex (hereafter BSK), documented over much of the Balkans

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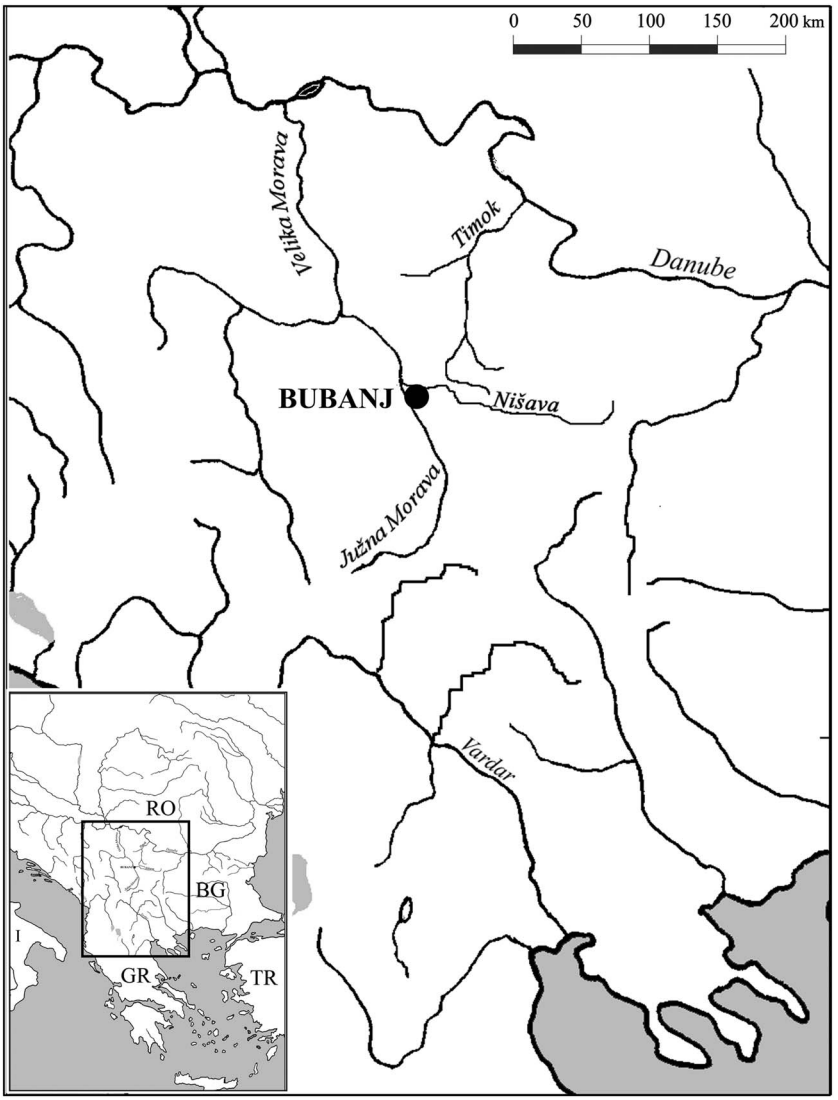

Figure 1 Location of the site of Bubanj, Serbia
(Drawing: A. Bulatović)

in western Bulgaria, southwestern Romania, Serbia, as well as parts of Macedonia, Albania, and Greece. Although ^{14}C dates for this cultural complex are relatively numerous, there is a great imbalance in their geographical distribution, with so far only a single date available for the central Balkans at the site of Bodnjik (western Serbia; Živanović 2013:54). As a result, precise chronological relationships between the regional variants of this complex remain poorly understood (e.g. lack of dates for Bubanj-Hum I in Serbia or Šuplevac-Bakarno Gumno in Macedonia; good chronology for both Salcuţa I-III in Romania and Krivodol I-II in Bulgaria: Boyadziev 1995; Lazarovici 2006). An overall attribution to the middle and/or second half of 5th millennium cal BC is widely accepted, on the basis of existing ^{14}C dates and typological comparisons with older complexes (e.g. Kodžadermen-Gumelniţa-Karanovo VI in northern Bulgaria and southern Romania: Boyadziev 1995; Nikolov and Petrova 2016; and

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Gradešnica-Slatino-Dikili Tash in southern Bulgaria and northern Greece: Boyadziev 1995; Roque et al. 2002).

For the Middle and Late Eneolithic, typological comparisons between Bubanj and other sites concern the Černavoda III and Baden-Boleraz cultures (hereafter ČV III-B-B complex), Koţofeni-Kostolac and Bubanj-Hum II cultures (Jovanović 1976; Tasić 1979; Garašanin 1982:153–5; Tasić 1995; Kapuran and Bulatović 2012). Typologically, the pottery assemblage from Bubanj belongs to the Černavoda III culture, but also presents numerous pottery typological traits echoing the central European Baden culture, especially its Boleraz horizon (Bulatović and Kapuran, forthcoming). Once more, the existing documentation is very unequal, with numerous dates for the Baden-Boleraz culture, mostly clustered in central Europe (Wild et al. 2001; Furholt 2008; Horvath 2008), while dates for the Černavoda III culture are so far only available for the site of Drama-Merdžumekja, in eastern Thrace (Bulgaria; Gleser & Thomas 2012). The Koţofeni-Kostolac culture (hereafter K-K), attributed to the Late Eneolithic, is also sparsely dated, with only a single date for the central Balkans at the site of Belovode in central Serbia, where a K-K layer was dated by chance in course of the analysis of Late Neolithic samples (Borić 2009:196, their Table 2). The Bubanj-Hum II group, although named after the site of Bubanj, will not be covered here as it was poorly represented in the recent excavations on which this paper is based (see below).

The situation is similar for the Early Bronze Age, a period for which the site of Bubanj is once more instrumental in the establishment of the relative chronology (cf. Bubanj-Hum III culture; hereafter BH III). The Serbian archaeological literature, in the near absence of any ^{14}C dates (but see Bogdanović 1986; Krstić et al. 1986:34; Gogaltan 1999), relies upon relative chronology and analogies with the material culture of neighbouring, absolutely dated cultures (Bulatović 2011), such as the Moriş (or Mokrin) culture to the north (O'Shea 1996) and Armenochori group to the south (Maniatis and Ziota 2011; Gori 2015), thus suggesting a date to the last quarter of the 3rd and the beginning of 2nd millennia BC.

Here, we fill this damaging gap by presenting the first ^{14}C dates obtained for the site of Bubanj, covering both the Eneolithic and the Early Bronze Age. These new results, all obtained on samples from recently excavated secure archaeological contexts, are then compared to dates surveyed from the literature for each of the aforementioned archaeological complexes, in order to test the validity of the chronological estimates based upon traditional typological comparisons.

METHODS

As previously mentioned, the site of Bubanj originally covered a total surface of approximately 3.5 ha, distributed over a western, central, and eastern area. Unfortunately, since the 1950s, the site has been subject to extensive destruction of various sorts. When a new archaeological field campaign was organized in 2008, only 200 m^2 located in the eastern area were available for scientific investigations. Excavations were regularly conducted between 2008 and 2014 by the Archaeological Institute in Belgrade and the National Museum in Niš, in the course of which a broad range of samples was acquired, including bone samples for ^{14}C analysis reported here. Excavations were organized over a total surface of 150 m^2, in a 1 × 1 m square grid, coupled with artificial excavation spits of 3–5 cm deep. Archaeological structures were excavated as distinct coherent units.

The stratigraphy covers the Early Eneolithic (BSK), which immediately rests upon the soil substrate, the Middle (ČVIII B-B) and Late Eneolithic (K-K), each represented by two distinct

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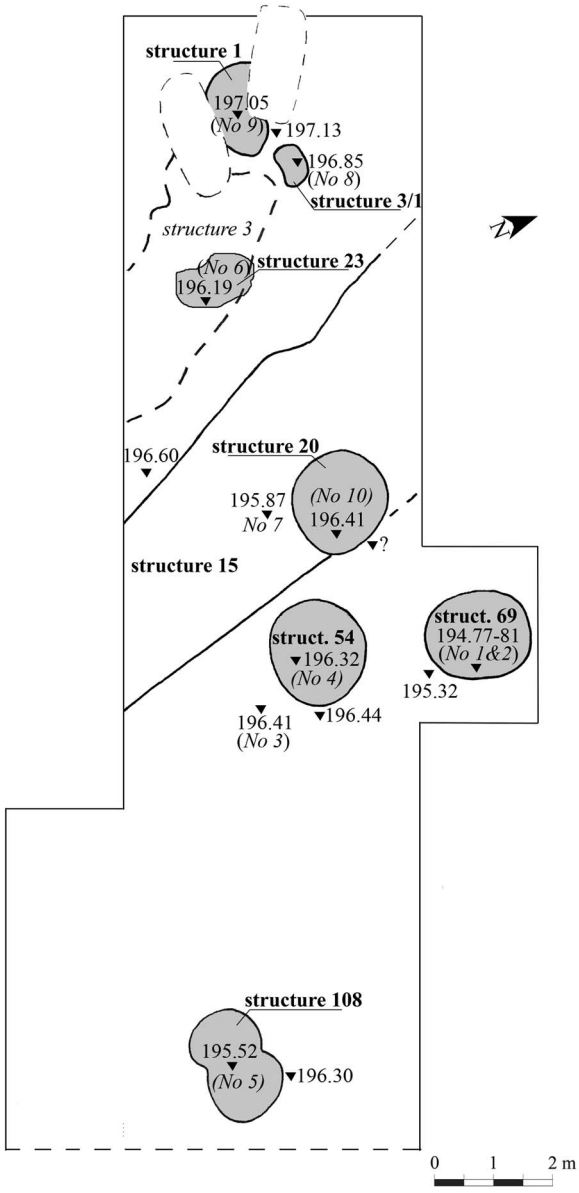

Figure 2 Plan of the 2008–2014 excavations in Bubanj (Drawing: A. Bulatović)

horizons, and the Early Bronze Age (BH III). Younger deposits are absent because of extensive soil erosion and recent activity on the site, although finds from various periods are found at the surface and in the upper, heavily disturbed, meter of the stratigraphy.

A total of 10 samples, covering the entire stratigraphic sequence, were selected for ^{14}C dating. All samples were taken from secure stratigraphic contexts (Figure 2), and were closely associated with typologically well-defined pottery production. To minimize the risks of dating residual samples, animal bones were privileged as part of the sampling strategy, and were all identified by

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an experienced zooarchaeologist prior to submission for dating. Nine samples were submitted for counting to the SUERC Radiocarbon Dating Laboratory in Glasgow, where they were treated following the standard protocol described by Dunbar and colleagues (Dunbar et al. 2016). One supplementary sample was obtained from the Centre de Datation par le Radiocarbone, Lyon. Calibration and further Bayesian modeling (see below) were performed using Oxcal 4.2 (Bronk Ramsey 2009), using Intcal 13 (Reimer et al. 2013). All results are reported in Table 1.

The oldest dates were provided by 2 animal bone samples recovered from the center of an Eneolithic pit (structure 69), possibly of ritual function (Bulatović 2015:30, their fig.3). Its opening is nearly circular (~1.7 m diameter), and its sides, deeply dug into the substrate (depth: 1.5 m) were fire-baked. Its fill includes a mix of pottery fragments (Figure 3: items 1–5), chipped stone tools, daub fragments, animal bones, ash, and other finds (Bulatović 2015: Pl. II). The pottery typology points to an attribution to the BSK complex. The Middle Eneolithic is dated by 4 samples coming from the 17th artificial excavation spit, 2 pits and a scatter of pottery and animal bones. Pit 108 was dug from the lower horizon of this cultural layer, and probably corresponds to a refuse pit (1.8 × 1.2 m, max depth 0.6 m). It contained large amounts of pottery fragments (Figure 3: items 7–10), animal bones, daub fragments, considerable quantity of burnt wood, a copper needle fragment, as well as other objects of baked earth and stone. The pottery belongs to the ČV III-B-B complex. Another dated pit (structure 54) has a nearly circular base, and was dug from the upper horizon of ČV III-B-B cultural layer (Table 1, row 4). It contained pottery fragments (Figure 3: item 11) and animal bones. We also obtained a date from a bone sample coming from feature 23 (Table 1, row 6), a scatter of pottery and animal bones found in the lower horizon of ČV III-B-B complex (196.16–196.24 m asl). Once more, the pottery typology clearly points to the ČV III-B-B complex (Figure 3: item 6). The last sample from this horizon (Table 1, row 3) comes from the excavation layer and contained pottery characteristic for ČV III-B-B complex.

Two samples were obtained from sealed contexts for the K-K horizon. A first sample was taken from the lower floor of a house (structure 15; Table 1, row 7), in direct association with K-K potsherds (Figure 3: items 12–16). The second sample (Table 1, row 8), comes from the base of another house (structure 3/1), from the younger K-K horizon (Figure 3: items 17–22), and is also directly associated with pottery characteristic for this culture. In the absence of secure stratigraphic contexts, it was decided not to take any sample from the layer above, in which material culture belonging to the Bubanj-Hum II group was found.

The Early Bronze Age (BH III group) is dated by finds coming from two secured stratigraphic contexts. The first sample (Table 1, row 10) comes from a deep pit, with a nearly circular base (approximate dimensions: diameter 1.4 m, depth 1.6 m; structure 20). Although the upper part of the pit had been recut by a Medieval grave, it presented an interesting succession of fills, suggesting a refusal function. It contained pottery fragments as well animal bones, daub fragments, and other finds (bone awl, chipped stone tools). The dated sample is identified as *Equus* species, although it is impossible to determine whether this corresponds to a wild or domesticated animal. The second sample comes from a shallow oval-shaped pit (structure 1) (Table 1, row 9), which contained numerous pottery fragments (Figure 3: items 23–28), and some animal bones.

RESULTS AND DISCUSSION

To improve the precision of our results, we built a Bayesian model in OxCal 4.2. Such an approach allows us to constrain the probability distribution of ^{14}C dates through the inclusion of robust,

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Table 1 Newly acquired ^{14}C dates for the site of Bubanj.

Sample, height (asl)	Context of sample (culture)	Date (BP)	Calibrated date BC (68.2%)	Calibrated date BC (95.4%)
Bone (*Cervus elaphus*) ▼194.81	Trench 2/Feature 69, ritual pit (BH I)	5452 ± 28	4343–4266	4351–4257
Bone (*Cervus elaphus*) ▼194.77	Trench 2/Feature 69, ritual pit (BH I)	5433 ± 30	4336–4262	4342–4245
Bone (*Bos taurus*) ▼196.41	Trench 2/Layer 17 (CV III-B-B)	4516 ± 32	3347–3115; 3236–3170 (30.6%)	3356–3098
Bone (*Bos taurus*) ▼196.32	Trench 2/Feature 54, shallow pit (CV III-B-B)	4529 ± 32	3355–3117; 3234–3172 (29.4%)	3361–3102
Bone (*Bos taurus*) ▼195.52	Trench 3/Feature 108, garbage pit (CV III-B-B)	4587 ± 37	3495–3138; 3381–3317 (41.2%)	3502–3109
Bone (*Bos taurus*) ▼196.19	Feature 23, scatter of pottery and animal bones	4615 ± 35	3517–3396 (63.6%); 3386–3339 (30.7%); 3517–3339 (94.3%)	3517–3144
Bone (*Capra hircus*) ▼196.60	Trench 1/Feature 15, from house floor (K-K)	4470 ± 37	3330–3037; 3330–3215 (43.8%)	3341–3024
Bone (*Ovis/capra*) ▼196.85	Trench 1/Feature 3/1, from house floor (K-K)	4393 ± 35	3083–2928; 3028–2928 (58.4%)	3263–2910
Bone (*Sus* sp.) ▼197.05	Trench 1/Feature 1, shallow pit (BH III)	3632 ± 34	2035–1942	2131–1900
Bone (horse *calcaneum*) ▼196.41	Trench 2/Feature 20, garbage pit (BH III)	3648 ± 32	2120–1950	2140–1920

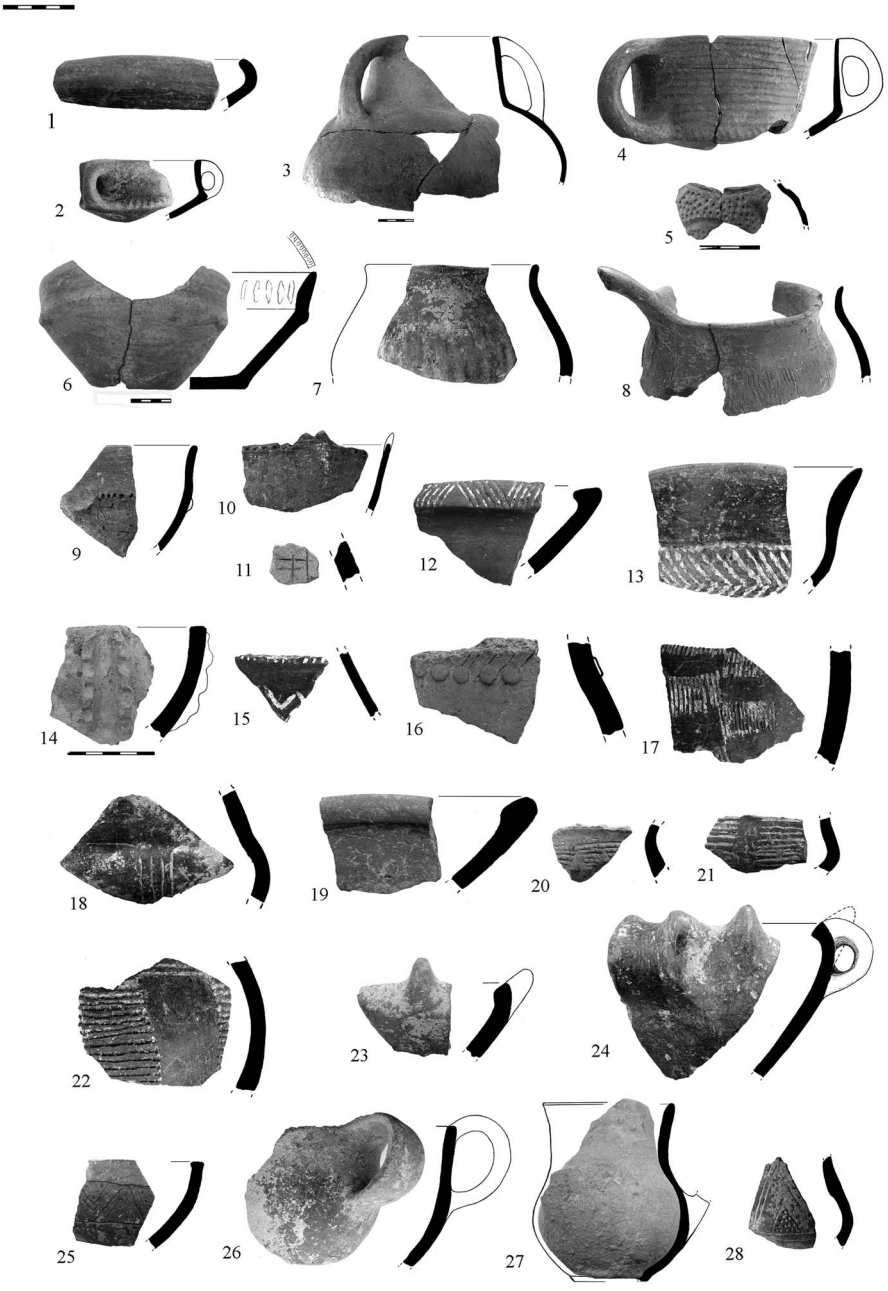

Figure 3 1–5: structure 69 (Bubanj-Hum I group); 6: structure 23 (ČV III-B-B complex); 7–10: structure 108 (ČV III-B-B complex); 11: structure 54 (ČV III-B-B complex); 12–16: structure 15 (K-K culture); 17–22: structure 3 (K-K culture); 23–28: structure 1 (Bubanj-Hum III group).

independent chronological data, known as prior information (Bronk Ramsey 2009). In this case, this prior information corresponds to the stratigraphic relationships between the samples. The resulting model includes as few assumptions as possible, with a single sequence of 4 bounded phases. The model presents an overall good agreement (Amodel: 102.9) (Figure 4).

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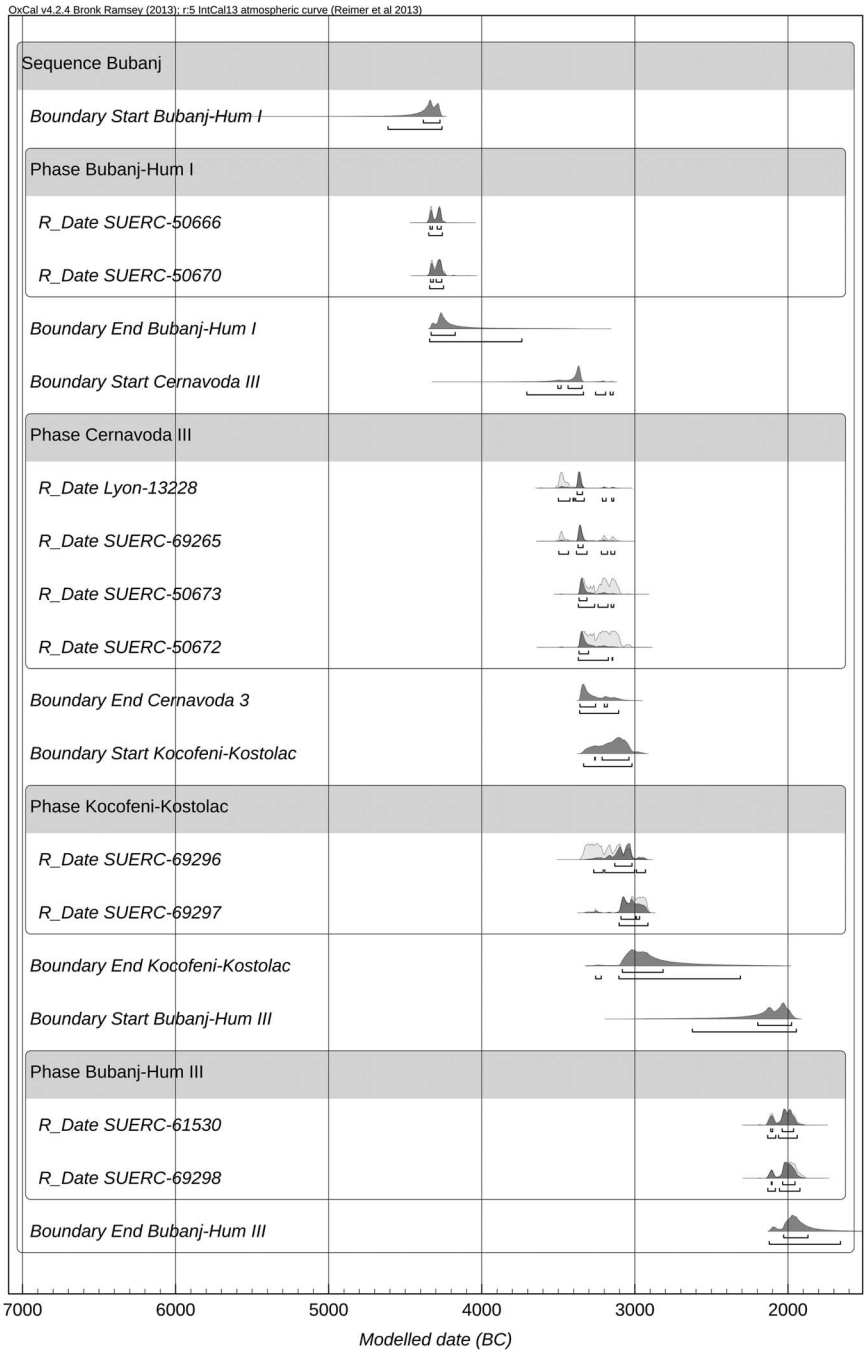

Figure 4 Bayesian modeling of the new ^{14}C dates for Bubanj.

On the basis of the Bayesian modeling, the BSK horizon in Bubanj starts in 4618–4259 cal BC (95.4% probability), possibly 4383–4273 cal BC (68.2% probability) and ends in 4341–3739 cal BC (95.4% probability), possibly 4331–4171 cal BC (68.2% probability), thus pointing to a

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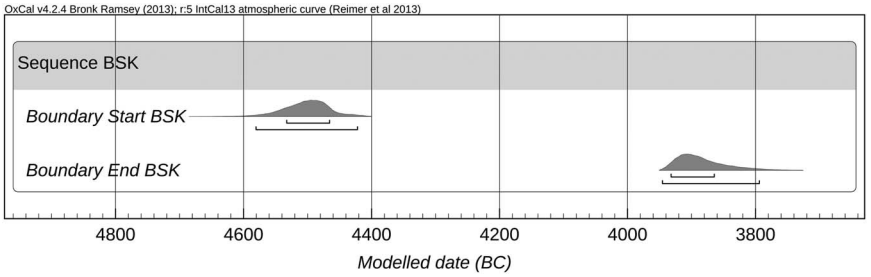

Figure 5 Bayesian modeling of ^{14}C dates for the BSK complex (dates listed in Table A1)

relatively short phase of use (duration: 0–68 yr, 95.4% probability; 0–30 yr, 68.2% probability). In order to compare this result with the overall development of the BSK complex, we compiled a dataset of all corresponding ^{14}C dates found in the literature (see Table A1 in Appendix). This dataset only lists 38 dates for 13 sites, including Bubanj, showing the reduced size of the documentation, mostly coming from Bulgaria and Romania. This dataset was then used to build another Bayesian model, considering the BSK complex as a single bounded phase (Figure 5). Such an approach provides quantitative estimates for the beginning and end of the modeled phase, which are more robust than mere visual inspections of the range of calibrated ^{14}C dates (Bayliss et al. 2007). This model (Amodel: 106.2) suggests that the BSK complex begins in 4573–4422 cal BC (95.4% probability), possibly 4530–4465 cal BC (68.2% probability), and ends in 3947–3806 cal BC (95.4% probability), possibly 3932–3869 cal BC (68.2% probability). Without much surprise given the small sample, the earliest expressions of the BSK complex are located in the well-dated areas, which are both western Bulgaria and Oltenia. Interestingly, the site of Bubanj lies slightly later in the sequence during the third quarter of the 5th millennium cal BC. Further precision is however hampered by the shape of the calibration curve for this period. The background of the emergence of the BSK complex has been discussed at length, especially regarding its relationship with the preceding Vinča culture. Recent Bayesian modeling of this culture, based on a much larger dataset, suggests that its later ceramic phase Vinča D began in 4870–4725 cal BC (95.4% probability), possibly in 4810–4740 cal BC (68.2% probability), and ended in 4515–4360 cal BC (95% probability), possibly in 4490–4415 cal BC (68.2% probability) (Whittle et al. 2016). The comparison between both models suggests an overlap of 1–2 centuries between both ceramic styles.

The second cultural phase represented in the new Bubanj excavations corresponds to the ČV III-B-B complex. Our Bayesian model suggests that this horizon began in 3717–3334 cal BC (91.3% probability), possibly 3434–3345 cal BC (62.8% probability), and ended in 3361–3106 cal BC (95.4% probability), possibly 3359–3258 cal BC (62.7% probability), with a duration spanning 1–3 centuries (duration: 0–275 yr, 95.4% probability; 0–79 yr, 63.7% probability). There is also a noticeable gap between this and the preceding BH I horizon, estimated to have lasted from 2 to more than 9 centuries (Interval BSK-ČV III: 223–983 yr, 92.4% probability; 673–953 yr, 68.2% probability). This situation is widely encountered across the territory of modern-day Serbia, where the archaeological record for the early 4th millennium cal BC is scanty, especially when compared to neighboring countries. It is impossible to assess whether this gap is a byproduct of modern research or reflects a past reality, though the last hypothesis should not be discarded as several recent studies in other European regions point to the existence of fluctuations in demographic regimes and settlement patterns (see review in Shennan 2012).

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The nature of the Baden culture, and its relationships with the Černavoda III culture have long been discussed, and chronology has prominently featured in this debate. The Baden culture is generally dated between 3650 and 2800 cal BC (Wild et al. 2001; Furholt 2008; Horváth et al. 2008). Furholt points to the existence of an early phase, characterized by coarse wares, dated to 3650–3350 cal BC, immediately followed by the Boleraz phase, dated to 3520–3350 cal BC, which is characterized by fine wares and a process of spatial expansion (Furholt 2008). Links between this Boleraz phase and the Černavoda III culture have been suggested on typological grounds (see below). Wild et al. (2001) rejected this hypothesis by showing, on the basis of few dates, the contemporaneity of the Baden culture with the Černavoda I culture, which supposedly precedes the Černavoda III one (Roman 1999). However, their argument is flawed by the fact that the precise contexts from which these dates were taken are contested (Nikolova 1999:89).

The overall chronological brackets of the Baden culture are confirmed by our own analysis of the literature, which included 113 dates distributed over 40 sites (Table A2). A simple Bayesian modeling of this dataset (Figure 6), as a single bounded phase, indeed confirms that the whole Baden culture began in 3667–3578 cal BC (95.4%), possibly 3652–3609 cal BC (68.2% probability), and ended in 2886–2824 cal BC (95.4% probability), possibly 2876–2846 cal BC (68.2% probability). We then compared these results with a similar Bayesian modeling of the few existing dates for the Černavoda III culture (Figure 6), which so far only consist of 5 dates from the sites of Drama-Merdžumekja (Bulgaria; Gleser and Thomas 2012), and the 4 dates for Bubanj reported here (Table A3). Given the scarcity of the evidence, we adopted a conservative approach by inserting all dates, although the oldest one (Erl-14441, 4751 ± 57 BP) presents a poor overall agreement (A = 55.6). The model suggests that the Černavoda III culture began in 3551–3353 cal BC (95.4% probability), possibly in 3416–3359 cal BC (68.2% probability), and ended in 3369–3166 cal BC (95.4% probability), possibly in 3358–3317 cal BC (68.2% probability). This confirms that the Černavoda III culture starts later than the beginning of the Baden culture, but is strictly contemporaneous with the Boleraz phase. Despite the controversy, such a result should not be surprising, given that numerous sites in the central Balkans present traits from both complexes in close association (e.g. lids of Bratislava type, bowls with funnel-shaped neck channeled on the interior, plastic appliques on rim and elsewhere, *Fischbute,* ball-shaped smaller pots decorated with vertical channels, bowls with everted S profile featuring accentuated shoulder ornamented with two horizontal rows of pitted dots and others; Bulatović and Kapuran, forthcoming). These new dates thus suggest that the process of spatial expansion associated with the Boleraz phase (Furholt 2008) had wider repercussions, exemplified by the presence of the aforementioned typological traits in the ČV III culture in the central Balkans.

The third cultural horizon represented in the new Bubanj excavation is associated with the K-K culture. According to the Bayesian model, this horizon began in 3335–3018 cal BC (95.4% probability), possibly 3108–3039 cal BC (66.2% probability) and ended in 3108–2326 (95.4% probability), possibly 3083–2821 cal BC (68.4% probability) (duration: 0–225 yr, 95.4% probability; 0–94 yr, 68.2% probability). This third horizon is separated from the previous ČVIII horizon by a compact grey layer, interpreted as a surface leveled on purpose by the settlers associated with the K-K horizon. This reading is partly confirmed by the rapid succession between both phases, estimated to 0–275 yr (95.4% probability), possibly 0–154 yr (68.2% probability). Based on already published dates (Figure 7; Table A4), we estimate the start of the K-K culture to 3352–3037 cal BC (95.4% probability), possibly 3205–3058 cal BC (68.2% probability), and its end to 2875–2667 cal BC (95.4% probability), possibly 2862–2771 cal BC (68.2% probability), thus confirming previous estimates (Nikolić 2000:78). The dates from Bubanj nearly cover the entire sequence of this culture, and appear to be roughly contemporaneous with both Kostolac (sites of Vučedol,

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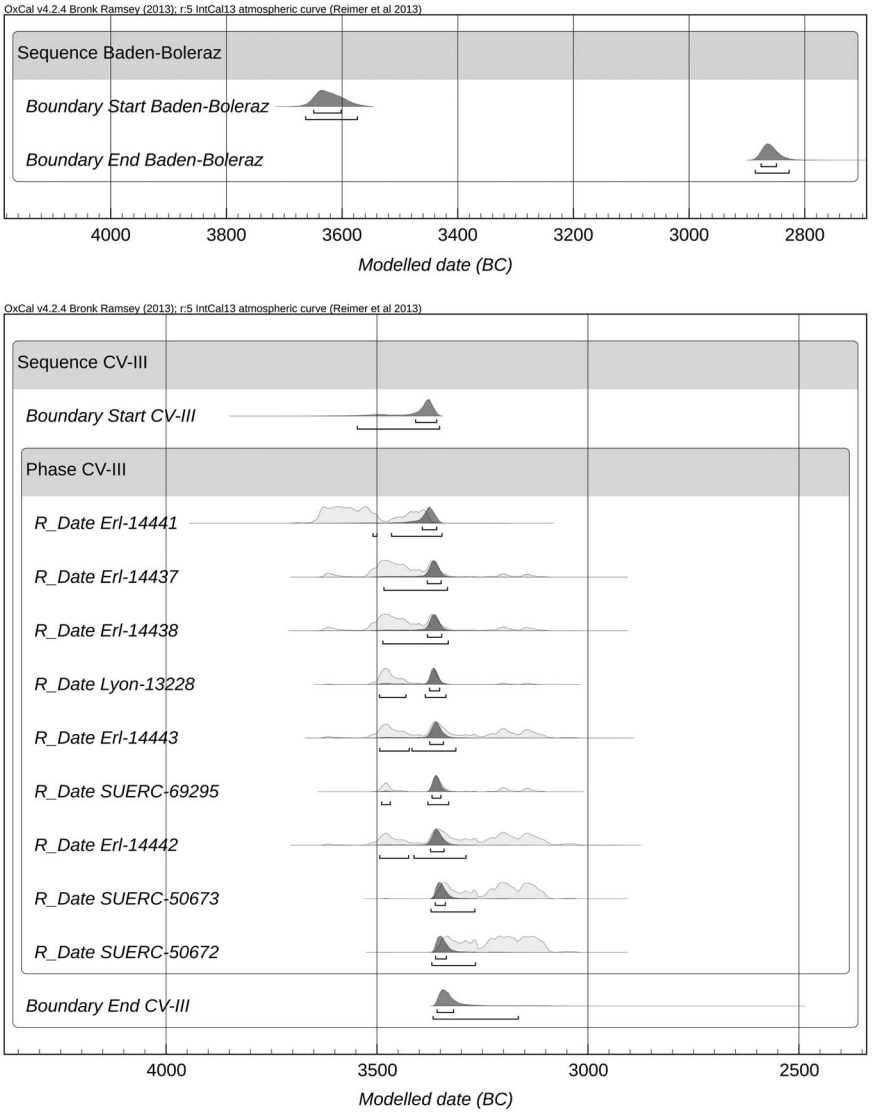

Figure 6 Top: Bayesian modeling of ^{14}C dates for the Baden culture (dates listed in Table A2). Bottom: Bayesian modeling of dates for the Černavoda III culture (dates listed in Table A3)

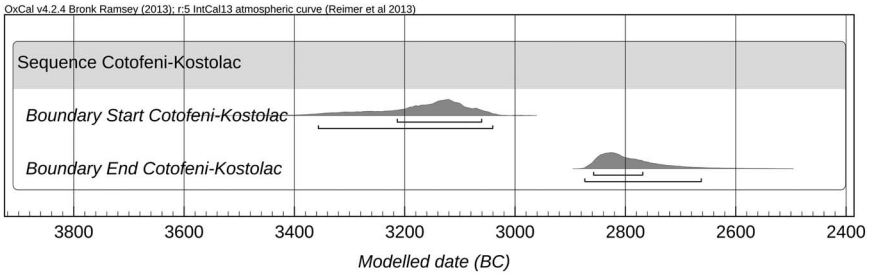

Figure 7 Bayesian modeling of ^{14}C dates for the Koţofeni-Kosolac complex (dates listed in Table A4)

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Pivnica and Gomolava; Waterbolk 1988; Benko et al. 1989; Bojadžiev 1992), and Koţofeni facies (Bojadžiev 1992, 1998:357).

Given the aforementioned poor preservation of the upper part of the stratigraphic profile, we were only able to obtain dates from secure contexts for the BH III layer, corresponding to the Early Bronze Age in the local terminology. The extensive damage occasioned to the stratigraphy is confirmed by the chronological gap between this horizon and the preceding one, estimated to 102–1080 yr (95.4%), possibly 575–1036 yr (68.4%). The BH III horizon in Bubanj began in 2624–1946 cal BC (95.4% probability), possibly 2191–1976 cal BC (68.2% probability), and ended by 2121–1652 cal BC (95.4% probability), possibly 2030–1869 cal BC (68.4% probability), and thus lasted a century at most (duration: 0–128 yr, 95.4% probability; 0–47 yr, 68.4% probability). These estimates are older than dates from the oldest horizon at the site of Ljuljaci, attributed to the proto-Vatin (Bogdanović 1986), or Bubanj-Hum IV-Ljuljaci group (Bulatović and Stankovski 2012:343–7), which is considered as the beginning of the Middle Bronze Age in the central Balkans. Dates for the BH III horizon at Bubanj are broadly contemporaneous with the Moriş (or Mokrin) culture from the Hungarian plain (Table A5; O'Shea 1996), and the Armenochori group in northern Greece (Table A5; Maniatis and Ziota 2011). These three cultural groups indeed share several stylistic and typological pottery traits (Garašanin 1982; Bulatović and Stankovski 2012).

CONCLUSION

These radiocarbon dates for the site of Bubanj, one of the key prehistoric locations in southeastern Europe, provide a breakthrough in the chronology of Eneolithic and Bronze Age periods in the central Balkans, as these correspond to the first absolute dates for certain prehistoric periods over this area.

The absolute dates for the BSK, K-K, and B-H III horizons all confirm the previous chronological estimates based on typological comparisons, and reinforce the importance of the site of Bubanj in the typological and cultural sequences of the Eneolithic and Early Bronze Age in the Balkans. The dates for the ČV III horizon are very significant. Not only do they provide the first dates for this culture in the central Balkans (and only the second for this entire culture), but they also indicate to a strict contemporaneity with the Boleraz phase of the Baden culture, thus pointing to the complex cultural interactions happening across central Europe during the late 4th millennium cal BC. Conversely, they cast doubt on the validity of the ČV I-ČV III sequence, although in this case inadequacies in the original dates for the ČV I culture cannot be ruled out.

All in all, this contribution calls for further sampling and dating of Eneolithic and Bronze Age sites across the Balkans. As we have shown here, significant results can be obtained through careful sampling combining robust stratigraphic and typological information, and a relatively limited number of dates, which makes the approach viable, especially in research areas where funding is often a limited resource.

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APPENDIX

Datasets: Tables A1–A5

Table A1 Dataset of all corresponding ^{14}C dates for Bubanj-Salkuta-Krivodol complex.

Country	Site	Lab nr	Date (BP)	STD	References
Bulgaria	Djakovo	Bln-2610	5620	100	Boyadžiev (1995)
Bulgaria	Haramijska Dupka	Bln-3340	5240	50	Boyadžiev (1995)
Bulgaria	Haramijska Dupka	Bln-3341	5250	60	Boyadžiev (1995)
Bulgaria	Haramijska Dupka	Bln-3342	5150	50	Boyadžiev (1995)
Bulgaria	Haramijska Dupka	Bln-3343	5190	60	Boyadžiev (1995)
Bulgaria	Haramijska Dupka	Bln-3344	5030	80	Boyadžiev (1995)
Bulgaria	Haramijska Dupka	Bln-3345	5150	50	Boyadžiev (1995)
Bulgaria	Krivodol	Bln-2113	5295	40	Boyadžiev (1995)
Bulgaria	Krivodol	Bln-2114	5445	45	Boyadžiev (1995)
Bulgaria	Lîga	Ua-20607	5545	45	Merkyte (2005)
Bulgaria	Lîga	Ua-20608	5650	45	Merkyte (2005)
Bulgaria	Lîga	Ua-20610	5490	45	Merkyte (2005)
Bulgaria	Lîga	Ua-21562	5160	45	Merkyte (2005)
Bulgaria	Lîga	Ua-21563	5215	55	Merkyte (2005)
Bulgaria	Lîga	Ua-21564	5450	35	Merkyte (2005)
Bulgaria	Pipra	Bln-2115	5295	45	Boyadžiev (1995)
Bulgaria	Teliš-Redudite	Bln-2240	5400	50	Boyadžiev (1995)
Bulgaria	Teliš-Redudite	Bln-2241	5240	50	Boyadžiev (1995)
Bulgaria	Teliš-Redudite	Bln-2242	5230	50	Boyadžiev (1995)
Bulgaria	Teliš-Redudite	Bln-2243	5295	70	Boyadžiev (1995)
Bulgaria	Teliš-Redudite	Bln-2244	5170	50	Boyadžiev (1995)
Bulgaria	Teliš-Redudite	Bln-2388	5330	50	Boyadžiev (1995)
Bulgaria	Yagodina	Bln-2245	5595	50	Boyadžiev (1995)
Bulgaria	Yagodina	Bln-2249	5000	50	Boyadžiev (1995)
Bulgaria	Yagodina	Bln-2250	5060	50	Boyadžiev (1995)
Bulgaria	Yagodina	Bln-2389	5265	50	Boyadžiev (1995)
Romania	Curmatura	Bln-1977	5710	45	Breunig (1987)
Romania	Ostrovul Corbului	Bln-2508	5460	60	Breunig (1987)
Romania	Ostrovul Corbului	—	5591	82	Breunig (1987)
Romania	Ostrovul Corbului	—	5260	60	Breunig (1987)
Romania	Ostrovul Corbului	SMU-585	5627	77	Breunig (1987)
Romania	Salcuţa	GrN-1985	5450	55	Ehrich and Bankoff (1992)
Romania	Salcuţa	GrN-1989	5450	55	Ehrich and Bankoff (1992)
Romania	Salcuţa	GrN-1990	5475	55	Ehrich and Bankoff (1992)
Serbia	Balač-Zemun Polje	OxA-26306	5438	34	Orton pers. comm
Serbia	Balač-Zemun Polje	OxA-26307	5421	35	Orton pers. comm
Serbia	Balač-Zemun Polje	OxA-26308	5585	34	Orton pers. comm
Serbia	Bubanj	SUERC-50666	5452	28	This study
Serbia	Bubanj	SUERC-50670	5433	30	This study
Serbia	Družetić-Bodnjik	OxA-26309	5579	35	Orton pers. comm

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Table A2 Dataset of ^{14}C dates for Boleraz-Baden culture.

Country	Site	Lab nr	Date (BP)	STD	References
Austria	Baierdorf	VERA-838	4645	35	Wild et al. (2001:1060)
Austria	Franzhausen	VERA-868	4510	40	Wild et al. (2001:1061)
Austria	Girm	VERA-875	4565	45	Wild et al. (2001:1061)
Austria	Girm	VERA-869	4530	50	Wild et al. (2001:1061)
Austria	Grub an der March	VERA-878	4790	55	Wild et al. (2001:1060)
Austria	Grub an der March	VERA-877	4760	50	Wild et al. (2001:1060)
Austria	Grub an der March	VERA-876	4770	55	Wild et al. (2001:1060)
Austria	Hadersdorf	VERA-881	4485	40	Wild et al. (2001:1061)
Austria	Hadersdorf	VERA-880	4510	45	Wild et al. (2001:1061)
Austria	Lichtenwörth	Bln-2071	4410	60	Wild et al. (2001:1061)
Austria	Lichtenwörth	Bln-2069	4540	45	Wild et al. (2001:1061)
Austria	Niederhollabrunn	ETH-15241	4710	95	Wild et al. (2001:1060)
Austria	Ossarn Stickelberger	GrN-6940	4520	40	Wild et al. (2001:1061)
Austria	Pottenbrunn	GrN-14016	4560	60	Wild et al. (2001:1061)
Austria	Stillfried	VERA-851	4645	35	Wild et al. (2001:1061)
Austria	Stillfried	VERA-850	4605	35	Wild et al. (2001:1061)
Austria	Straß im Straßertale	VERA-893	4515	45	Wild et al. (2001:1061)
Austria	Zillingtal	VERA-861	4700	45	Wild et al. (2001:1060)
Austria	Zillingtal	VERA-860	4625	35	Wild et al. (2001:1060)
Switzerland	Arbon Bleiche	B-6365	4660	40	Wild et al. (2001:1060)
Switzerland	Arbon Bleiche	B-6364	4620	40	Wild et al. (2001:1060)
Switzerland	Arbon Bleiche	B-6363	4690	30	Wild et al. (2001:1060)
Switzerland	Arbon Bleiche	B-6362	4640	30	Wild et al. (2001:1060)
Switzerland	Arbon Bleiche	B-6361	4700	30	Wild et al. (2001:1060)
Switzerland	Arbon Bleiche	B-6360	4710	30	Wild et al. (2001:1060)
Czech Republic	Hlinsko	GrN-6942	4670	45	Wild et al. (2001:1060)
Czech Republic	Hlinsko	GrN-6941	4670	40	Wild et al. (2001:1060)
Czech Republic	Hlinsko	GrN-16729	4605	40	Wild et al. (2001:1060)
Czech Republic	Hlinsko	GrN-16728	4650	40	Wild et al. (2001:1060)
Czech Republic	Hlinsko	GrN-13149	4750	60	Wild et al. (2001:1060)
Czech Republic	Hlinsko	Bln-3233	4680	60	Wild et al. (2001:1060)
Czech Republic	Hlinsko	Bln-3232	4780	70	Wild et al. (2001:1060)
Czech Republic	Hlinsko	Bln-1396	4775	60	Wild et al. (2001:1060)
Czech Republic	Hlinsko	Bln-1166	4670	80	Wild et al. (2001:1060)
Czech Republic	Hlinsko	Bln-1165	4670	80	Wild et al. (2001:1060)
Austria	Schwechat	VERA-849	4935	45	Wild et al. (2001:1060)
Czech Republic	Beladice	Bln-2171	4420	60	Wild et al. (2001:1060)
Hungary	Gyöngyöshalász	Bln-2589	4790	50	Wild et al. (2001:1060)
Hungary	Nagykanizsa	VERA-840	4455	50	Wild et al. (2001:1061)
Hungary	Nagykanizsa	VERA-841	4425	40	Wild et al. (2001:1061)
Hungary	Nagykanizsa	VERA-843	4400	40	Wild et al. (2001:1061)
Hungary	Nagykanizsa	VERA-844	4425	35	Wild et al. (2001:1061)
Hungary	Nagykanizsa	VERA-846	4080	40	Wild et al. (2001:1061)
Hungary	Ószentiván VIII	Bln-476	4515	80	Kohl and Quitta (1970)
Hungary	Sümeg	A-246	4520	60	Wild et al. (2001:1060)
Hungary	Szigetcsép	Bln-1637	4350	45	Wild et al. (2001:1060)
Hungary	Szihalom	VERA-852	4785	40	Wild et al. (2001:1060)
Hungary	Szihalom	VERA-853	4740	40	Wild et al. (2001:1060)
Hungary	Szihalom	VERA-854	4830	40	Wild et al. (2001:1060)
Hungary	Szihalom	VERA-855	4850	60	Wild et al. (2001:1060)
Hungary	Szihalom	VERA-856	4785	35	Wild et al. (2001:1060)
Hungary	Szihalom	VERA-857	4755	35	Wild et al. (2001:1060)
Hungary	Szihalom	VERA-862	4735	35	Wild et al. (2001:1060)
Hungary	Szihalom	VERA-863	4745	35	Wild et al. (2001:1060)

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Table A2 (*Continued*)

Country	Site	Lab nr	Date (BP)	STD	References
Hungary	Vámosgyörk	VERA-903	4475	45	Wild et al. (2001:1060)
Hungary	Vámosgyörk	VERA-904	4400	45	Wild et al. (2001:1060)
Poland	Iwanowive	Bln-352	4200	100	Wild et al. (2001:1060)
Slovakia	Bajc-Vlkanovo	VERA-736	4530	45	Wild et al. (2001:1060)
Slovakia	Cervený Hrádok	GrN-11994	4390	70	Wild et al. (2001:1060)
Slovakia	Červený Hrádok	GrN-11992	4820	70	Wild et al. (2001:1060)
Slovakia	Červený Hrádok	GrN-11993	4710	100	Wild et al. (2001:1060)
Slovakia	Podolie	Bln-556	4455	80	Wild et al. (2001:1060)
Slovakia	Šarišské Michalany	VERA-769	4385	35	Wild et al. (2001:1060)
Slovakia	Svodín	Bln-2169	4270	50	Wild et al. (2001:1060)
Slovakia	Svodín	Bln-2173	4460	60	Wild et al. (2001:1060)
Slovakia	Svodín	Bln-2174	4390	60	Wild et al. (2001:1060)
Serbia	Gomolova	GrN-13168	4380	70	Wild et al. (2001:1060)
Croatia	Vučedol	Z-1446	4540	86	Forenbaher (1993)
Croatia	Vučedol	Z-1466	4540	130	Forenbaher (1993)
Croatia	Vučedol	Z-1617	4500	100	Forenbaher (1993)
Croatia	Vučedol	Z-1618	4300	100	Forenbaher (1993)
Croatia	Vučedol	Z-1619	4400	100	Forenbaher (1993)
Croatia	Vučedol	Z-1864	4626	100	Forenbaher (1993)
Hungary	Balatonősződ-Temetői dűlő	Deb-13244	4440	60	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13277	4520	60	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13286	4440	45	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13291	4550	80	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13292	4380	45	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13374	4390	60	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13379	4480	70	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13381	4110	50	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13382	4360	45	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13386	4330	35	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13387	4310	50	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13389	4200	35	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13395	4460	50	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13398	4680	45	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13411	4445	45	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13412	4440	70	Horváth et al. (2008)
Hungary	Balatonősződ-Temetői dűlő	Deb-13425	4220	50	Horváth et al. (2008)
Czech Republic	Brno Lisen II	Erl-6434	4748	51	Furholt (2008)
Czech Republic	Brno Lisen III	Erl-6433	4710	49	Furholt (2008)
Poland	Bronocice	DIC-361	4240	115	Breunig (1987)
Poland	Bronocice	DIC-543	4320	130	Breunig (1987)
Poland	Bronocice	DIC-977	4320	55	Breunig (1987)
Poland	Bronocice	DIC-978	4250	115	Breunig (1987)
Poland	Bronocice	DIC-979	4200	60	Breunig (1987)
Czech Republic	Hlinsko	UtC-13773	4620	60	Furholt (2008)
Poland	Iwanowice Babaia-Gora I-38b	UtC-13267	4300	44	Furholt (2008)
Poland	Iwanowice Babia Gora I-1	UtC-13264	4365	43	Furholt (2008)
Poland	Iwanowice Babia Gora I-18	UtC-13265	4336	44	Furholt (2008)
Poland	Iwanowice Babia Gora I-21	UtC-13266	4380	50	Furholt (2008)
Poland	Iwanowice Babia Gora I-62	UtC-13268	4362	43	Furholt (2008)
Czech Republic	Jevisovice B	Erl-6432	4745	49	Furholt (2008)
Czech Republic	Jevisovice C1	Erl-6431	4670	50	Furholt (2008)
Czech Republic	Jevisovice C2	Erl-6430	4821	50	Furholt (2008)
Poland	Kraków-Pleszów	GrN-9181	4430	40	RADON database

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Table A2 (*Continued*)

Country	Site	Lab nr	Date (BP)	STD	References
Poland	Kraków-Pleszów	GrN-9265	4445	60	RADON database
Serbia	Padej	Bln-2219	4320	50	RADON database
Poland	Wojnowice	UtC-13259	4356	46	Furholt (2008)
Poland	Wyciaze 50	UtC-13263	4542	43	Furholt (2008)
Poland	Zeslawice 140a	UtC-13261	4420	43	Furholt (2008)
Poland	Zeslawice 97	UtC-13260	4387	45	Furholt (2008)

Table A3 Dataset of ^{14}C dates for Černavoda III culture.

Country	Site	Lab nr	Date (BP)	STD	References
Serbia	Bubanj	SUERC-50672	4516	32	This study
Serbia	Bubanj	SUERC-50763	4529	32	This study
Serbia	Bubanj	SUERC-69295	4587	37	This study
Serbia	Bubanj	Lyon-13228	4615	35	This study
Bulgaria	Drama-Merdžumekja	Erl-14443	4592	57	Gleser (2011)
Bulgaria	Drama-Merdžumekja	Erl-14442	4575	62	Gleser (2011)
Bulgaria	Drama-Merdžumekja	Erl-14441	4751	57	Gleser (2011)
Bulgaria	Drama-Merdžumekja	Erl-14438	4626	55	Gleser (2011)
Bulgaria	Drama-Merdžumekja	Erl-14437	4629	53	Gleser (2011)

Table A4 Dataset of ^{14}C dates for Koţofeni-Kostolac culture.

Country	Site	Lab nr	Date (BP)	STD	References
Serbia	Bubanj	SUERC-69296	4470	37	This study
Serbia	Bubanj	SUERC-69297	4393	35	This study
Romania	Ostrovul Corbului	Lj-3797	4520	60	Breunig (1987)
Croatia	Vučedol	Z-1821	4500	150	Benkő et al. (1989)
Bosnia and Herzegovina	Pivnica	Kn-232	4500	55	Bojadžiev (1992)
Romania	Băile Herculane	Lj-3533	4460	100	Breunig (1987)
Serbia	Gomolova	GrN-7372	4445	70	Waterbolk 1988)
Serbia	Belovode	OxA-14678	4431	36	Borić (2009)
Romania	Ostrovul Corbului	Lj-3798	4420	50	Breunig (1987)
Romania	Ostrovul Corbului	Lj-3799	4400	60	Breunig (1987)
Croatia	Vučedol	Z-1820	4370	140	Benkő et al. (1989)
Romania	Băile Herculane	Lj-3534	4360	100	Breunig (1987)
Serbia	Gomolova	GrN-7371	4360	60	Waterbolk (1988)
Romania	Băile Herculane	Lj-3535	4350	60	Breunig (1987)
Romania	Băile Herculane	Lj-3536	4300	60	Breunig (1987)
Bosnia and Herzegovina	Pivnica	GrN-8010	4290	60	Bojadžiev (1992)
Romania	Poiana Ampoiului	Bln-4621	4260	41	Ciugudean (1996)
Romania	Poiana Ampoiului	Bln-4620	4239	40	Ciugudean (1996)
Serbia	Gomolova	GrN-13167	4210	60	Waterbolk (1988)
Romania	Poiana Ampoiului	UZ -2869/ETH-9277	4085	70	Ciugudean (1996)
Romania	Poiana Ampoiului	UZ -2870/ETH -9278	4030	75	Ciugudean (1996)
Romania	Poiana Ampoiului	UZ-2668/ETH-9276	3755	70	Ciugudean (1996)

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Table A5 Dataset of ^{14}C dates for cultures of Early Bronze Age in central Balkans.

Country	Site	Lab nr	Date (BP)	STD	References
Serbia	Bubanj	SUERC-69298	3632	34	This study
Serbia	Bubanj	SUERC-61530	3648	32	This study
Serbia	Mokrin	GrN-14179	3690	30	O'Shea (1996)
Serbia	Mokrin	GrN-14178	3655	30	O'Shea (1996)
Serbia	Mokrin	GrN-7977	3650	50	O'Shea (1996)
Serbia	Mokrin	GrN-14180	3650	35	O'Shea (1996)
Serbia	Mokrin	GrN-14181	3595	35	O'Shea (1996)
Greece	Xeropigado Koiladas	DEM-810	3920	33	Maniatis and Ziota (2011)
Greece	Xeropigado Koiladas	DEM-1215	3380	38	Maniatis and Ziota (2011)
Croatia	Vinkovci	KIA-29562	3881	78	Kalafatić 2006
Croatia	Vinkovci	Z-1817	3810	78	Durman and Obelić (1989)
Albania	Sovjan	Ly-11918	3770	40	Gori (2015)
Serbia	Omoljica	BC-2	3530	60	Gogaltan (1999)
Serbia	Ljuljaci	Z-546	3480	60	Gogaltan (1999)

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