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ABSOLUTE CHRONOLOGY OF THE ZEDMAR CULTURE: RE-THINKING RADIOCARBON DATES

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Abstract: The Zedmar culture is linked with the subneolithic circle of the South-Eastern Baltic region. So far, excavations have been carried out only on seven archaeological sites. Nonetheless, there are quite a lot of radiocarbon measurements. Most of them refer to the stratigraphic contexts. This allows to integrate all of the data into statistical models. With these, it is possible to query some statements about the Zedmar culture origin and its duration. At least as long as placing the Zedmar culture into an absolute timescale may offer any solution to those issues.
The idea that radiocarbon dates could provide solutions or even final answers to some arguable questions in prehistorical studies was dropped, as soon as it became clear that in the whole approach the key role is played by calibration methods and the general variability of sampled material.
However – thanks to including Bayesian analysis, a better understanding of dated materials and more complex examination of received results – it has been asserted again.

Keywords: the Zedmar culture, Subneolithic, South-Eastern Baltic, radiocarbon dating, modelled chronology.

1. INTRODUCTION

The Zedmar culture (later: ZC) is one of the subneolithic cultures from the South-Eastern Baltic area. It was located (**Fig. 1**) in the eastern part of Kaliningrad Oblast of Russia and the northern part of the Masurian Lake District in Poland. First research was carried out by Prussian prehistorians at the beginning of the 20th century and later by Russian and Polish archaeologists. Despite a rather long history of research, many questions about the ZC phenomenon still remain.

The ZC, also known as the Serovo culture or the Zedmar type materials, is sometimes regarded as a local group of subneolithic Neman or Narva cultures (for more details see: Borowik-Dąbrowska and Kempisty, 1981; Gumiński, 1999, 2001; Czerniak, 2007, 2008; Timofeev, 1998; Kukawka, 2010).

In that varied nomenclature at least one is certain: the ZC is part of the subneolithic[1] world, established by late hunter-fisher-gatherer communities that were producing pottery. Still an important question is: how to describe the genesis of the Zedmar tradition? Should it be brought together with a wider cultural complex of East European roots or excluded from the mosaic of the Baltic Subneolithic? This is linked with the origin of pottery making in the area under study as well as the beginning of the ZC. In the literature there are a few theories which involve different subneolithic or neolithic cultures in that process

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[1] For more terminological issues related with the Subneolothic definition see: Kempisty, 1983; Werbart, 1994, 1998.

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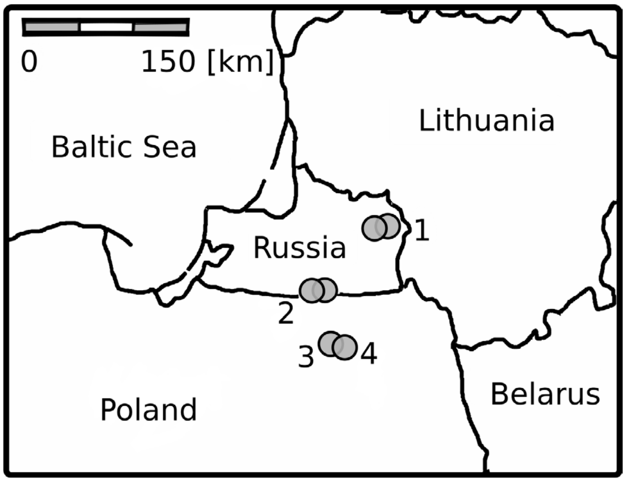

Fig. 1. *The ZC site location. 1 – Utinoe Boloto 1 and 2, 2 – Zedmar A and D, 3 – Dudka, 4 – Szczepanki 8 and 8A (www.d-maps.com/m/europa/baltique/baltique20.gif; modified).*

(for example: Gumiński, 2011a). There are opposing opinions about the end of the ZC tradition. Some researchers suggest the ZC might have contributed to the development of one of the Late Neolithic cultures (Zalcman, 2010) or even might have lasted almost until the Early Bronze Age (Gumiński, 2001, 2005). Others see it more briefly (Kukawka, 2015). There is a lack of strong premises in archaeological assemblages to support or to prove the falsity of both hypotheses. The aim of the study is to create an absolute chronology of the ZC, after analysing radiocarbon data with Bayesian tools. The article is based on the author's unpublished bachelor's thesis and in a few cases related to absolute chronology of the South-East Baltic Neolithic, also presents results from master's degree thesis.

2. METHODOLOGICAL BACKGROUND

Since 1969 there have been many radiocarbon dates obtained from the ZC sites and 58 (**Table 1**) may be used in the further calculation with Bayesian analyses. They have been taken from seven sites, but, unfortunately, not all of them correspond to the ZC layers directly. As a result, for seven known and archaeologically excavated sites, only four have more than one radiocarbon date. What is more, only two of them (Dudka and Zedmar A) have sets of datings which can be used as a base in creating a sequence model. Unluckily, insufficient data makes it impossible to calculate them with a more precise tool (for example there are not known exact depths for each sample – for details see: Gumiński, 2001, 2005, 2014; Gumiński and Fiedorczuk, 1990; Timofeev *et al.*, 1995, 1998). A similar situation is taking place in the case of Szczepanki sites 8 and 8A, where all ^{14}C estimations (Gumiński, 2005; 2011b) were gathered from different trenches in order to build one chronological model. From Utinoe Boloto 1 and 2 came two radiocarbon dates (Timofeev, 1980). All the remaining radiocarbon dates were derived from Zedmar D site. They were obtained from five potsherds made in different technologies (two with a mineral admixture in clay mass and three with an organic). Two radiocarbon dates were estimated for each sherd. Both samples were prepared in a different way – INS and SOL fraction – (for a more detailed description see: Timofeev *et al.*, 1995, 1998). Also from Zedmar D came the so-called "E group" selected from charcoal and wood fragments (Timofeev *et al.*, 1995, 1998). The "L group", which was also collected from Zedmar D, was excluded from further consideration, because it was linked with a younger settling episode (Timofeev *et al.*, 1995, 1998).

All gathered dates were calibrated and modelled with OxCal v. 4.2.4 (https://c14.arch.ox.ac.uk) with IntCal13 (Reimer *et al.*, 2013). Parameters were written after Bronk Ramsey, 2008 and 2009. The entire set of ^{14}C estimations was modelled with Sequence command (more complex models are impossible to apply due to the lack of stratigraphic data) or R_Combine parameter. The results are rounded to ten years and are given with 68.2% probability range in the paper unless stated differently. For comparison 95.4% confidence intervals are reported in tables. Agreement indices for each modelled radiocarbon dating are also applied into the tables.

All of the ZC sites excavated up to now have been peat bogs. Peat layers could accumulate in a quite turbulent way (see: Tobolski, 2000; Walanus and Goslar, 2009). This allows to raise a question if an application of any of stratigraphically based models into the analysis of the ZC sites is trustworthy. Especially when one is considering Zedmar A chronological model or stratigraphical schema from Szczepanki 8 and 8A.

There is one more issue which has to be noted. Putting aside some deposition controversy and old wood effect – which might be discussed in the case of all of the ZC sites – there are a few additional important problems with pottery dating. As long as it is not charred food or organic temper itself that is dated, there is a possibility of dating not the 'target event' (for description see: Richter *et al.*, 2009: 711; a similar point of view Kukawka, 2010; Walanus and Goslar, 2009) but rather the natural component of clay (for discussion on that matter: Goslar *et al.*, 2013; Kovaliuch and Skripkin, 2007; Kukawka, 2010). Maybe this is the reason why a few dates obtained from pottery fragments with mineral admixture seem to be older, although the authors of the study had tried to avoid such contamination (for description see: Timofeev *et al.*, 1995, 1998). Even when sampling charred food for radiocarbon measurements one should also bear in mind that it might have come from cooking fish. This can result in a reservoir effect (compare: Lilie *et al.*, 2009) which might be the case in the potsherd from Szczepanki 8. However, without a more detailed analysis of residue, it is only one of the possible explanations.

Table 1. *The radiocarbon dates obtained from the ZC sites.*

No.	Lab no.	Age BP	Material	Notes	References
				DUDKA	
1	Gd-5575	7420 ± 80	-	Late Mesolithic	Gumiński, 1998: 103
2	Gd-5942	6910 ± 80	-	Late Mesolithic	Gumiński, 1998: 103
3	Poz-3913	6645 ± 30	Human bone	Grave VI-17; with one "post Zedmar" potsherd	Gumiński, 2014: 125
4	Gd-5944	6270 ± 70	-	Late Mesolithic	Gumiński, 1998: 103
5	Gd-5365	5540 ± 60	-	Trench II	Gumiński and Fiedorczuk, 1990: 54
6	Gd-2878	4960 ± 90	-	Trench II	Gumiński and Fiedorczuk, 1990: 54
7	Gd-4457	4880 ± 120	-	Leyer with the Late Neolithic, Trench III	Gumiński and Fiedorczuk, 1990: 69
8	Gd-2593	4870 ± 110	-	Trench II	Gumiński and Fiedorczuk, 1990: 54
9	Gd-4871	4320 ± 120	-	Leyer with the Late Neolithic, Trench III	Gumiński, 1998: 103
				SZCZEPANKI 8	
10	Poz-9384	5580 ± 40	Charred food	A potsherd with organic and mineral admixture, from layer with "early Zedmar" materials and the Mesolith-ic	Gumiński, 2005: 57; 2011b: 90
11	Sz8-BA*	2900 ± 60	-	The Bronze Age layer	Gumiński, 2011b: 90
12	MKL-596	3980 ± 40	-	The layer with the Late Neolithic and the Early Bronze Age materials	Gumiński, 2011b: 90
				SZCZEPANKI 8A	
13	Poz-48943	5360 ± 35	The orna-mented oar	The layer with "early Zedmar" materials and the Mesolithic	Gumiński, 2011b: 90
				UTINOE BOLOTO 1	
14	Le-1237	4870 ± 230	Charcoal	-	Timofeev, 1980: 14
				UTINOE BOLOTO 2	
15	UB-2*	4920 ± 200	Bone frag-ment	Experimental date from LOIA lab	Timofeev, 1980: 45
				ZEDMAR A	
16	Le-1343	4260 ± 80	Charcoal	Layer above teh upper horizon, which is linked with younger assemblages	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
17	Le-1270	6000 ± 90	Piece of wood	The pole dug into the ZC layer	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
18	Le-1388	4920 ± 80	Charcoal	The upper horizon	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
19	Le-1389	5100 ± 60	Charcoal	The upper horizon	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
20	Bln-2165	5120 ± 50	Charcoal	The upper horizon	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
21	Le-1319	4730 ± 140	Gyttja	The second layer	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
22	Bln-2164	5100 ± 50	Gyttja	The second layer	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
23	Bln-2163	5300 ± 60	Gyttja	Above the lower horizon	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
24	Le-1386	4870 ± 80	Charcoal	The lower horizon	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
25	Le-1387	4900 ± 80	Charcoal	The lower horizon	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
26	Le-3923	5130 ± 100	Charcoal	The lower horizon	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
27	Bln-2162	5280 ± 50	Charcoal	The lower horizon	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
28	Le-1268	4955 ± 110	Charcoal	From the bottom of the The lower horizon	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
29	Le-1269	5440 ± 90	Charcoal	From the bottom of the The lower horizon	Timofeev, 1980: 9; Timofeev *et al.*, 1998: 74
				ZEDMAR D	
30	Le-3626	4890 ± 100	Gyttja	The "E group"	Timofeev *et al.*, 1995: 23; 1998: 72-73
31	Le-3921	5640 ± 300	Antler tool	The "E group"	Timofeev *et al.*, 1995: 25; 1998: 73
32	Le-3924	5070 ± 150	Gyttja	The "E group"	Timofeev *et al.*, 1995: 25; 1998: 73
33	Le-3179	4880 ± 50	Piece of wood	The "E group"	Timofeev *et al.*, 1995: 25; 1998: 73
34	Le-3173	4990 ± 45	Piece of wood	The "E group"	Timofeev *et al.*, 1995: 25; 1998: 73
35	Le-3174	5090 ± 50	Piece of wood	The "E group"	Timofeev *et al.*, 1995: 25; 1998: 73
36	Le-3181	5150 ± 100	Piece of wood	The "E group"	Timofeev *et al.*, 1995: 25; 1998: 73
37	Le-3176	5170 ± 70	Piece of wood	The "E group"	Timofeev *et al.*, 1995: 25; 1998: 73
38	Le-3925	3870 ± 290	Piece of wood	The "L group"	Timofeev *et al.*, 1995: 25; 1998: 73
39	Le-3168	3890 ± 60	Piece of wood	The "L group"	Timofeev *et al.*, 1995: 25; 1998: 73
40	Le-3171	4250 ± 40	Piece of wood	The "L group"	Timofeev *et al.*, 1995: 25; 1998: 73
41	Le-3169	4300 ± 40	Piece of wood	The "L group"	Timofeev *et al.*, 1995: 25; 1998: 73
42	Le-3992	4120 ± 100	Piece of wood	The "L group"	Timofeev *et al.*, 1995: 25; 1998: 73
43	Le-3177	4170 ± 45	Piece of wood	The "L group"	Timofeev *et al.*, 1995: 25; 1998: 73
44	Le-3170	4210 ± 45	Piece of wood	The "L group"	Timofeev *et al.*, 1995: 25; 1998: 73
45	Le-1181	4020 ± 80	Piece of wood	The "L group"	Timofeev *et al.*, 1995: 25; 1998: 73

Table 1. *Continuation.*

No.	Lab no.	Age BP	Material	Notes	References
46	Ta-1173	4350 ± 80	Piece of wood	The "L group"	Timofeev *et al.*, 1995: 25; 1998: 73
47	Le-848	4180 ± 50	Piece of wood	The "L group"	Timofeev *et al.*, 1995: 25; 1998: 73
48	Le-1176	4240 ± 90	Piece of wood	The "L group"	Timofeev *et al.*, 1995: 25; 1998: 73
49	Ua-2375	5180 ± 100	Charred food	An organic admixture, the potsherd 1, INS fraction	Timofeev *et al.*, 1995: 25; 1998: 73
50	Ua-2376	5120 ± 100	Charred food	An organic admixture, the potsherd 1., SOL fraction	Timofeev *et al.*, 1995: 25; 1998: 73
51	Ua-2377	5030 ± 100	Charred food	An organic admixture, the potsherd 2., INS fraction	Timofeev *et al.*, 1995: 25; 1998: 73
52	Ua-2378	4950 ± 90	Charred food	An organic admixture, the potsherd 2., SOL fraction	Timofeev *et al.*, 1995: 25; 1998: 73
53	Ua-2379	4840 ± 100	Charred food	An organic admixture, the potsherd 3., INS fraction	Timofeev *et al.*, 1995: 25; 1998: 73
54	Ua-2380	5100 ± 100	Charred food	An organic admixture, the potsherd 3., SOL fraction	Timofeev *et al.*, 1995: 25; 1998: 73
55	Ua-2381	4810 ± 100	Charred food	A mineral admixture, the potsherd 4., INS fraction	Timofeev *et al.*, 1995: 25; 1998: 73
56	Ua-2382	5230 ± 100	Charred food	A mineral admixture, the potsherd 4., SOL fraction	Timofeev *et al.*, 1995: 25; 1998: 73
57	Ua-2383	5360 ± 130	Charred food	A mineral admixture, the potsherd 5., INS fraction	Timofeev *et al.*, 1995: 25; 1998: 73
58	Ua-2384	5280 ± 80	Charred food	A mineral admixture, the potsherd 5., SOL fraction	Timofeev *et al.*, 1995: 25; 1998: 73

**Lab no. unknown, substitute name.*

3. RESULTS AND DISCUSSION

The Dudka site sequence of radiocarbon dates is a little incomplete, but even such an insufficient number of radiocarbon dates, when treated together, can give more precise information about the age of the studied events (for similar opinion see: Bayliss *et al.*, 2007; Dee *et al.*, 2013; Michczyński, 2011; Walanus and Goslar, 2009). Results are presented in **Table 2**. To narrow the intervals Mesolithic and Late Neolithic dates were built into the model. Thanks to this it was possible to estimate a more credible dating of the Middle/Late Neolithic culture settling episode. It may be seen especially in the case of the Gd-4457 sample (3900–3520 calBC separately calibrated; 3670–3370 calBC in a sequence – **Fig. 2**) which corresponds a little better with other dates of similar materials from neighbouring regions (*ca.* 3100 calBC). It still seems to be an outlier, but its agreement index is not so poor – 83.4 (when the overall for the model is 85.6).

From Dudka came the palynological profile, which was reported in 1995 (Nalepka). It seems that palynological and archaeological dating "is in agreement" (Nalepka, 1995: 64). However, radiocarbon date taken for the level with the early ZC (Gd-2593 sample) seems to be younger (Nalepka, 1995: 63–4). According to Nalepka (1995: 63), the disagreement may be caused by sampling material for radiocarbon dating not directly from the palynological profile. As it may be seen in **Table 2** this sample corresponds quite well with the created model and there are no indicators that it may be an outlier. Perhaps this is another suggestion of how complex the process of layer accretion in Dudka was. Or how many data is missing in such simple model as presented in **Fig. 2**.

Table 2. *Results from Dudka sequence (OxCal v. 4.2.4).*

Phase	Boundary	Lab no.	Unmodelled age with 68.2% confidence interval (BC)	Unmodelled age with 95.4% confidence interval (BC)	Modelled age with 68.2% confidence interval (BC)	Modelled age with 95.4% confidence interval (BC)	Agreement
Late Mesolithic	start				6650–6170	7310–6070	
		Gd-5575	6400–6220	6440–6090	6380–6100	6420–6070	91.3
		Gd-5942	5890–5720	5990–5660	5890–5720	5990–5660	99.9
		Gd-5944	5330–5070	5470–5030	5370–5200	5470–5060	101.3
	end				5290–4880	5360–4550	
Early Zedmar	start				4760–4360	5110–4320	
		Gd-5365	4450–4340	4500–4260	4450–4330	4500–4260	99
Early/Middle Zedmar	Zedmar				4100–3690	4390–3660	
		Gd-2878	3920–3640	3970–3530	3910–3650	3950–3630	105.2
		Gd-2593	3790–3520	3950–3370	3900–3630	3950–3540	101.8
	Middle/ Late Zedmar-Late Neolithic				3760–3530	3870–3390	
Late Neolithic		Gd-4457	3900–3520	3960–3370	3670–3370	3760–3350	83.4
		Gd-4871	3320–2700	3350–2620	3490–2950	3630–2700	79
	end of Zedmar				3340–2740	3610–2030	

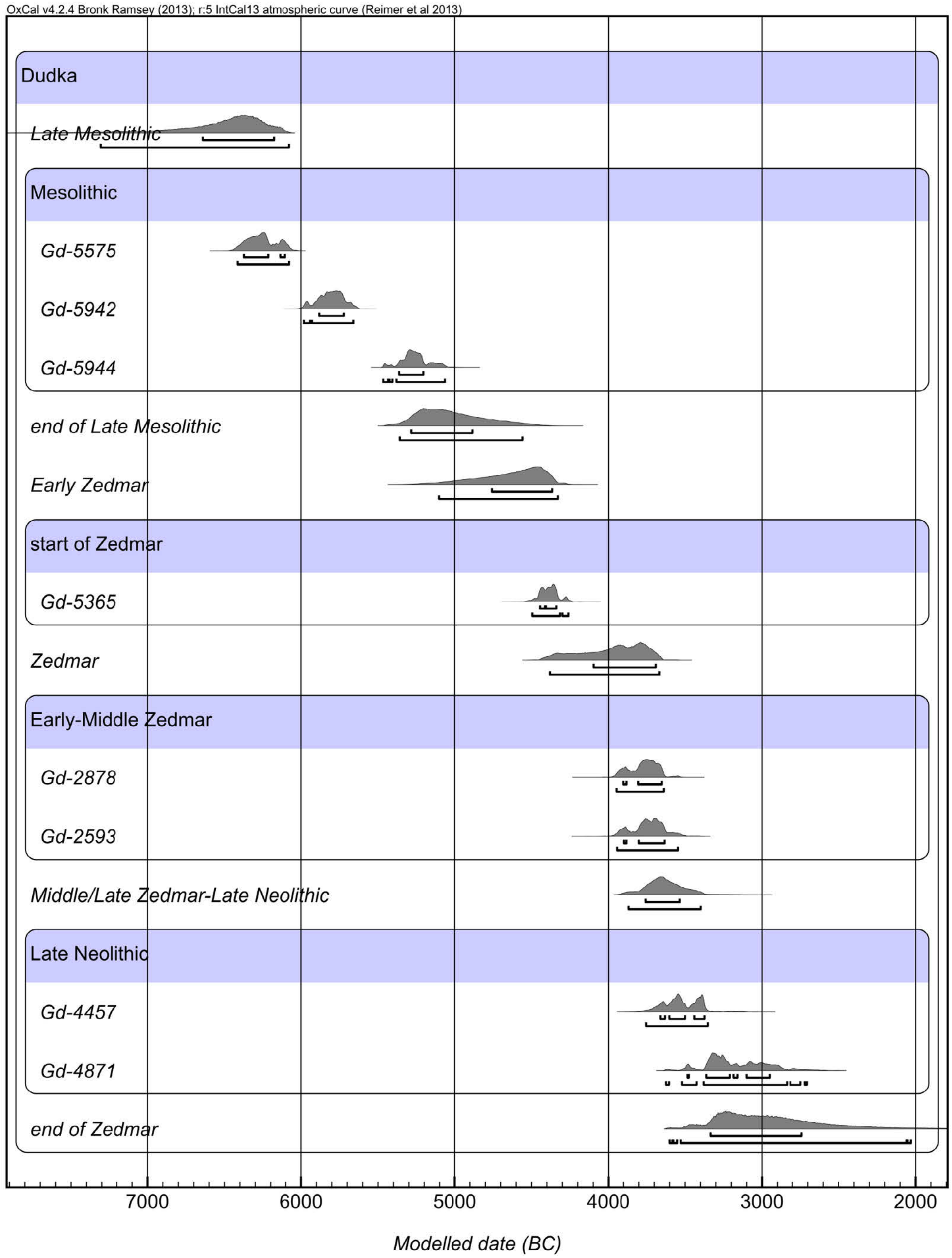

Fig. 2. *Sequence model for Dudka (OxCal v. 4.2.4).*

There is one more radiocarbon date from the Dudka site, taken from human bone, that may be linked with the ZC (Poz-3913 6645±30). However, the potsherd, which was found in the same grave, was described as the Late Neolithic and the dating result suggests Mesolithic chronology (Gumiński, 2014). This allowed archaeologist W. Gumiński (2014) to make an assumption of possible material mixing. Therefore, that sample was excluded from further consideration in this study.

Poz-9384 sample from Szczepanki 8, taken from charred food on a potsherd, after calibration gives 4490–4350 calBC with 95.4% confidence interval. Altogether with the other datings from Szczepanki 8 and Szczepanki 8A it may be treated as one stratigraphical schema (results in **Table 3**). It should be noted that the model was created after comparing stratigraphical and palinological analyses, which are quite compatible – **Fig. 3** (also overall agreement for a model is quite high – 99.2), although

Table 3. *Results from Szczepanki sequence (OxCal v. 4.2.4).*

Phase	Boundary	Lab no.	Unmodelled age with 68.2% confidence interval (BC)	Unmodelled age with 95.4% confidence interval (BC)	Modelled age with 68.2% confidence interval (BC)	Modelled age with 95.4% confidence interval (BC)	Agreement
Mesolithic/Early Zedmar	start				4650–4360	5280–4340	
		Poz-9384	4450–4360	4490–4340	4440–4350	4490–4340	101
		Poz-48943	4320–4070	4330–4050	4330–4160	4330–3110	100.9
	end				4310–3840	3930–2410	
Late Neolithic/Early Bronze Age	start				3180–2470	2620–2340	
		MKL-596	2570–2460	2620–2340	2570–2460	2570–1390	98.7
	end				2550–1960	2180–960	
Bronze Age	start				1580–1030	1280–920	
		Sz8-BA	1200–1000	1260–920	1210–1010	1360BC–120AD	97.9
	end				1210–750		

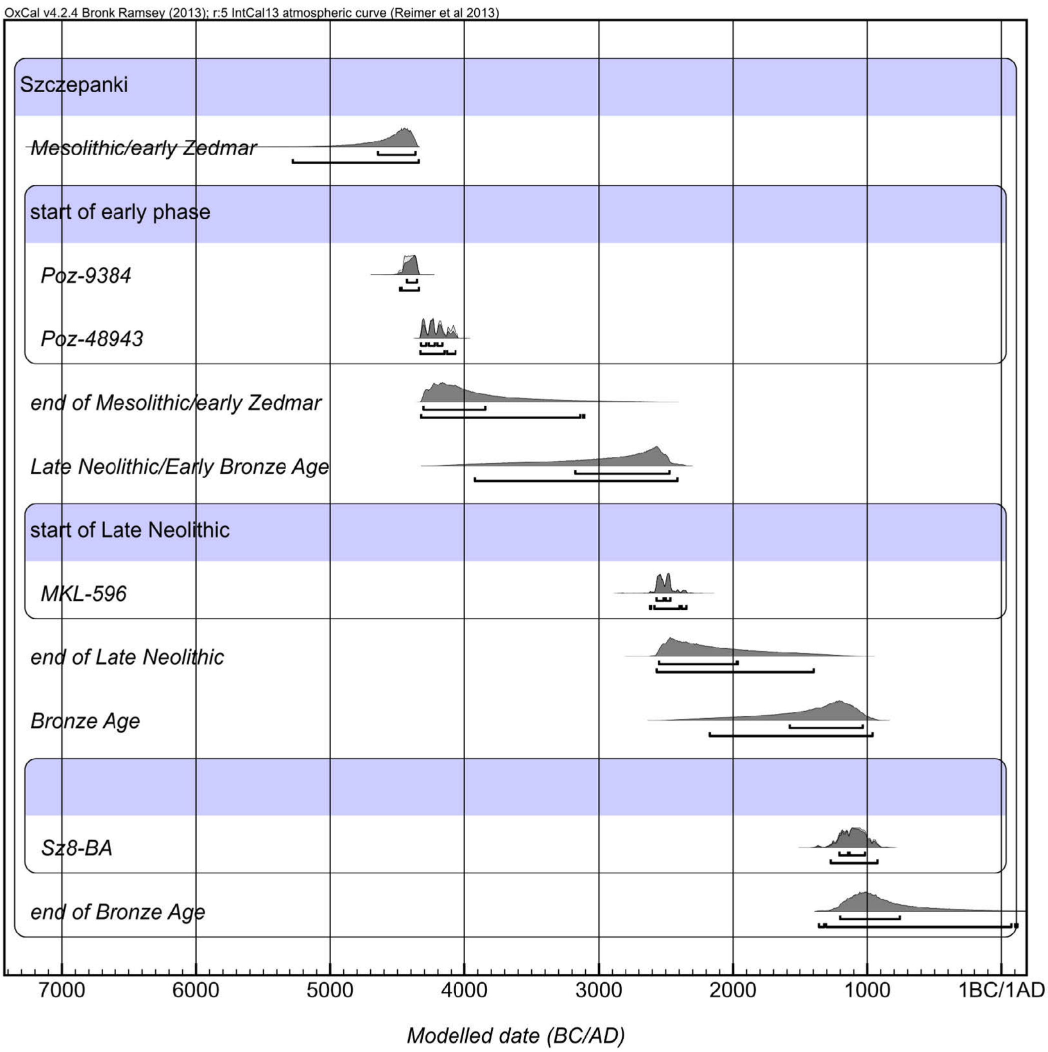

Fig. 3. *Sequence model for Szczepanki 8 and 8A after correlated stratigraphical data (OxCal v. 4.2.4).*

the data were obtained from different trenches (Gumiński, 2011b).

Singular dates from Utinoe Boloto 1 and 2 have large uncertainties (Timofeev, 1980). The Le-1237 sample after calibration is dated 3950–3370 calBC in 68.2% probability range and 4240–3030 in 95.4% probability range. The UB-2 sample from Utinoe Boloto 2 is dated 3970–3380 in 68.2% confidence interval and 4240–3120 calBC in 95.3% confidence interval. Each sample covers *ca.* 600 years even with a 1σ interval, which makes the closer chronological analysis impossible.

Modelled age for the ZC layers from Zedmar A may be seen in **Table 4**. Overall agreement index for the model is 76.2. However, looking at all the dates obtained from Zedmar A (**Table 1**), it may be seen that a few dates do not correspond with given order. The Le-1270 sample at a guess estimate can be considered as an outlier. Moreover, a few failed calculations due to low agreement indices and were excluded from the final sequence (**Fig. 4**) – Le-1269, Le-1268, Le-3923, Le-1387, Le-1396, Bln-2163, Le-1319. According to Michczyński (2011: 174–175), it is possible in a complex model to accept dates with agreement indices under 60%, but in the case presented above, the difference seems to be too high (much under 50%). It may be caused by disturbed material accretion on peat-bog sites and/or dating older wood fragments.

The "E group" of radiocarbon datings from Zedmar D was modelled with Boundary and Phase command (results in **Table 5**). Its agreement index is 94.9 after the Le-3921 sample has been excluded (it had a very poor agreement – 37.2).

Combined intervals were created for Zedmar D ceramics. Results were derived from every two dates of each pottery sherd (**Table 6**), from both fractions (**Table 7**) and from both tempers (**Table 8**). It is quite troublesome to determine which (if any) of those results are more convenient. An archaeologist would say that ranges which were received for combined sherds with the same temper, while a radiocarbon lab worker would probably suggest a separate treatment of every sherd and/or dates from two fractions. There is a possibility that all the radiocarbon dates for Zedmar D collected from pottery sherds should not be treated in the way mentioned above (combining all of the dates from the pottery together) - for example, because of their lack of homogeneity (they could be deposited in more than one settling episode, so they do not represent the same event).

The variations in samples' ages might also be caused by different laboratory preparation of samples – this is especially evident when taking into consideration INS and SOL fraction from the fourth potsherd. It is incorrect to combine both dates obtained from this piece of ceramic, because of failing a X^2 test (**Table 6**, **Fig. 6**).

Due to the lack of certainty over the homogeneity of the analysed material, there are two versions of sequence model with Boundary and Phase parameters (**Tables 9** and **10**). When comparing those results it may be seen that pottery with a mineral temper has an older chronology than that with an organic temper. Then the Ua-2381 sample is an outlier (**Table 9**) – as in the case of combining all ^{14}C dates for a mineral admixture. Another possibility is that the INS fraction is a better (but still not perfect) way to prepare samples with a mineral temper (at least in this case). As like this, the Ua-2381 sample is only one correct date for ceramic vessels with a non-organic admixture and corresponds quite well with the

Table 4. *Results from Zedmar A sequence (OxCal v. 4.2.4).*

Phase	Boundary	Lab no.	Unmodelled age with 68.2% confidence interval (BC)	Unmodelled age with 95.4% confidence interval (BC)	Modelled agewith 68.2% confidence interval (BC)	Modelled age with 95.4% confidence interval (BC)	Agreement
Lower horizon	start				4290–4090	4480–4000	
		Bln-2162	4230–4000	4240–3980	4240–4100	4320–4000	99.4
	end				4220–4060	4250–3970	
Gyttja above lower horizon	start				4140–3980	4210–3920	
Sand intrusion					4070–3930	4150–3870	
Gyttja second layer	start				4000–3890	4060–3830	
		Bln-2164	3970–3800	3990–3770	3970–3860	3990–3820	98.8
	end				3950–3850	3980–3810	
Upper horizon	start				3900–3810	3950–3790	
		Bln-2165	3980–3800	4040–3790	3860–3790	3930–3760	95.1
		Le-1389	3970–3800	4040–3710	3860–3790	3920–3710	102.5
		Le-1388	3800–3630	3950–3530	3870–3730	3910–3650	74.4
	end				3850–3680	3920–3480	
Late Neolithic	start				3430–2890	3730–2780	
		Le-1343	3020–2690	3100–2610	3330–2860	3350–2680	72.2
	end				3310–2710	3340–2470	

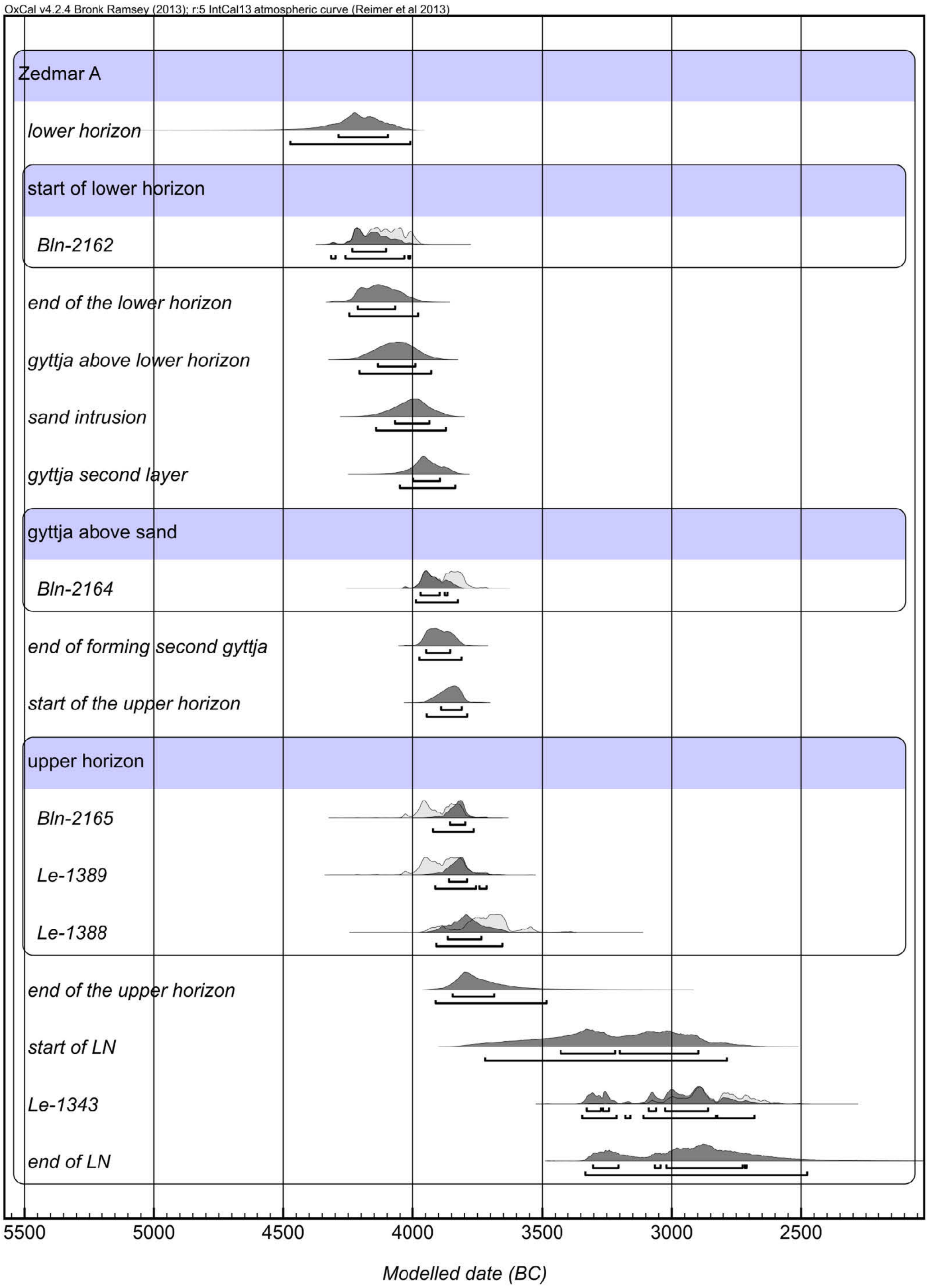

Fig. 4. *Sequence model for Zedmar A (OxCal v. 4.2.4).*

other samples taken from the second technological group.

After comparing those results with each other and with the other dates from Zedmar D (**Fig. 5**) it is possible to exclude at least a few samples obtained from potsherds (mainly with mineral admixture). It seems that it would be more reasonable to date the ceramics from Zedmar D in-between 4060/3790–3780/3480 calBC, basing on the model from combined radiocarbon dates obtained from potsherds with organic temper and the Ua-2381 in 68.2% confidence interval. Again – it is possible that ^{14}C estimations for Zedmar D (taken from pottery and the so-called "E group") came from various settlement phases. But for what is known for now, all of the materials may be treated as deposited in one event – as long as there is no clear indication how to separate data.

Table 5. *Results from modelling so-called "E-group" from Zedmar D (OxCal v. 4.2.4).*

Phase	Boundary	Lab no.	Unmodelled age with 68.2% confidence interval (BC)	Unmodelled age with 95.4% confidence interval (BC)	Modelled age with 68.2% confidence interval (BC)	Modelled age with 95.4% confidence interval (BC)	Agreement
Early group	start				4040–3830	4210–3790	
		Le-3176	4050–3810	4230–3790	3990–3790	4050–3760	84.1
		Le-3181	4050–3790	4240–3710	3970–3770	4040–3700	103.6
		Le-3174	3960–3800	3990–3760	3950–3790	3980–3760	100
		Le-3924	4040–3690	4260–3530	3910–3710	4010–3640	120.5
		Le-3173	3910–3700	3950–3650	3900–3700	3940–3660	103.9
		Le-3626	3800–3530	3950–3380	3810–3650	3950–3620	102.2
		Le-3179	3710–3630	3780–3530	3780–3640	3900–3630	78.1
	end				3750–3600	3890–3410	

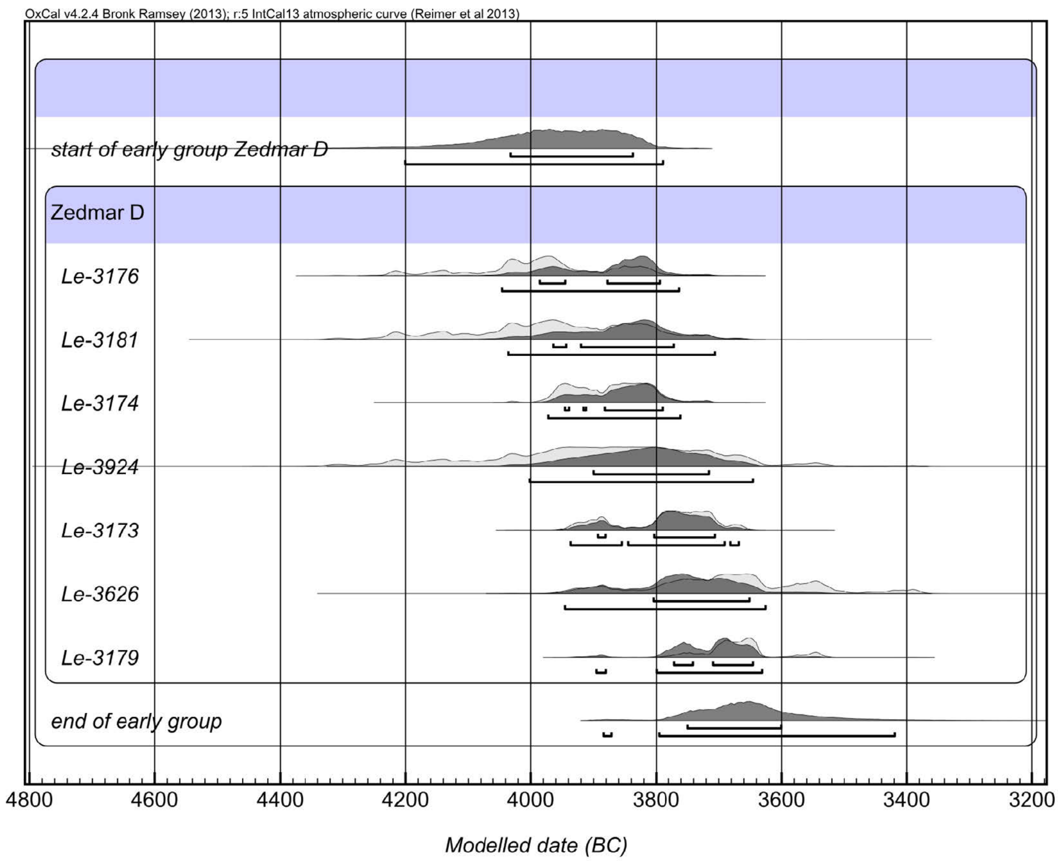

Fig. 5. *The so-called "E-group" from Zedmar D (OxCal v. 4.2.4).*

It is worth mentioning that before World War II there were also palinological analyses conducted by H. Gross on two sites of the ZC (Gaerte, 1929; Okulicz, 1973). Unfortunately, some documentation and many artefacts have gone missing. From the published data it is known that the Zedmar site and the Moczyska site (later recognized as Dudka – Gumiński and Fiedorczuk, 1990) were settled at a similar time (Okulicz, 1973) – but further excavations and material analyses failed to find a correlation with those results (Borowik-Dąbrowska and Kempisty, 1981). Still, they may be used as a premise for synchronic or shorter time settling of the ZC sites.

Comparing results of the modelled age of the older layer from Szczepanki with the younger one and with the results estimated for Zedmar A it seems that the interval finishing older phase (4310–3840 calBC) is more trustworthy when one determines Szczepenki chronology.

What can be said about the ZC absolute chronology is that it may be estimated between 4240 and 3480 calBC. The beginning of it was taken from the modelled age of

Table 6. *Combined ^{14}C dates for each potsherd from Zedmar D (OxCal v. 4.2.4).*

Potsherd	Lab no.	Unmodelled age with 68.2% confidence interval (BC)	Unmodelled age with 95.4% confidence interval (BC)	Notes
1		4050–3800	4230–3770	
	Ua-2375	4230–3800	4260–3710	
	Ua-2376	4040–3780	4230–3690	
2		3930–3670	3950–3650	
	Ua-2377	3950–3710	4040–3640	
	Ua-2378	3910–3640	3970–3530	
3		3910–3660	3950–3640	
	Ua-2379	3770–3380	3930–3370	
	Ua-2380	4040–3770	4230–3650	
4		3950–3710	3970–3660	X-test failed
	Ua-2381	3700–3380	3800–3360	
	Ua-2382	4230–3960	4330–3800	
5		4240–4040	4330–3980	
	Ua-2383	4330–4050	4470–3820	
	Ua-2384	4240–3990	4330–3960	

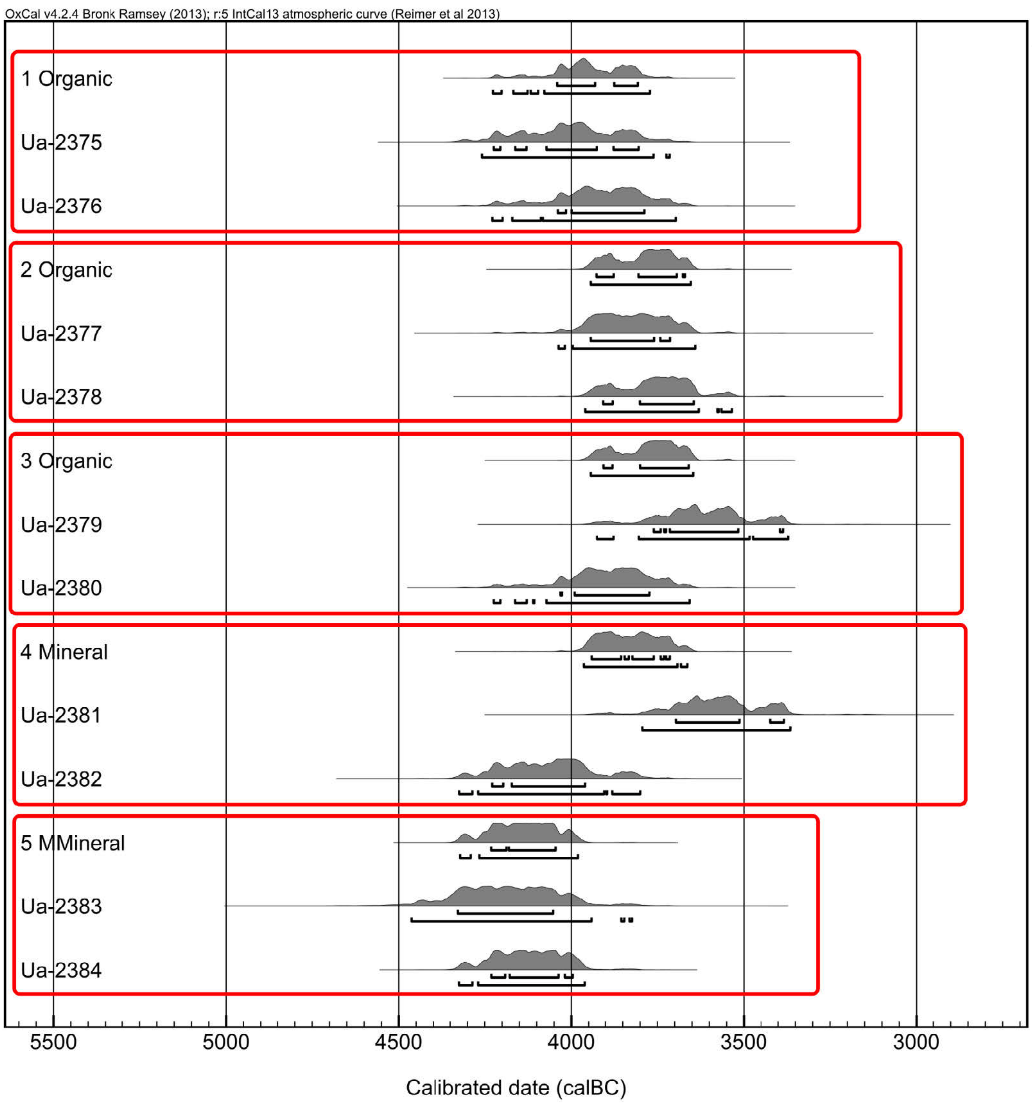

Fig. 6. *Combined ^{14}C estimations for each potsherd (OxCal v. 4.2.4).*

Table 7. *Combined ^{14}C dates for each fraction from Zedmar D potsherds (OxCal v. 4.2.4).*

Fraction	Lab no.	Unmodelled age with 68.2% confidence interval (BC)	Unmodelled age with 95.4% confidence interval (BC)	Notes
INS older		4050–3810	4230–3790	
	Ua-2383	4330–4050	4470–3820	Mineral temper, potsherd 5
	Ua-2375	4230–3800	4260–3710	Organic temper, potsherd 1
	Ua-2377	3950–3710	4040–3640	Organic temper, potsherd 2
INS younger		3700–3520	3770–3370	
	Ua-2379	3770–3380	3930–3370	Organic temper, potsherd 3
	Ua-2381	3700–3380	3800–3360	Mineral temper, potsherd 4
SOL		4040–3810	4050–3800	
	Ua-2384	4240–3990	4330–3960	Mineral temper, potsherd 5
	Ua-2382	4230–3960	4330–3800	Mineral temper, potsherd 4
	Ua-2376	4040–3780	4230–3690	Organic temper, potsherd 1
	Ua-2380	4040–3770	4230–3650	Organic temper, potsherd 3
	Ua-2378	3910–3640	3970–3530	Organic temper, potsherd 2

Table 8. *Combined ^{14}C dates for organic and mineral temper from Zedmar D (OxCal v. 4.2.4). Result from mineral temper after excluding the Ua-2381 sample.*

Temper	Lab no.	Unmodelled age with 68.2% confidence interval (BC)	Unmodelled age with 95.4% confidence interval (BC)	Notes
Organic		3950–3770	3960–3710	
	Ua-2376	4040–3780	4230–3690	Organic temper, potsherd 1
	Ua-2375	4230–3800	4260–3710	Organic temper, potsherd 1
	Ua-2378	3910–3640	3970–3530	Organic temper, potsherd 2
	Ua-2377	3950–3710	4040–3640	Organic temper, potsherd 2
	Ua-2379	3770–3380	3930–3370	Organic temper, potsherd 3
	Ua-2380	4040–3770	4230–3650	Organic temper, potsherd 3
Mineral		4230–4000	4260–3970	
	Ua-2382	4230–3960	4330–3800	Mineral temper, potsherd 4
	Ua-2383	4330–4050	4470–3820	Mineral temper, potsherd 5
	Ua-2384	4240–3990	4330–3960	Mineral temper, potsherd 5

Table 9. *Results from modelling combined ^{14}C dates for each potsherd (OxCal v. 4.2.4). The fourth potsherd was excluded from calculations.*

Phase	Boundary	Name	Unmodelled age with 68.2% confidence interval (BC)	Unmodelled age with 95.4% confidence interval (BC)	Modelled age with 68.2% confidence interval (BC)	Modelled age with 95.4% confidence interval (BC)	Agreement	Notes
Zedmar D potsherds	start				4280–3990	4800–3830		
		1 O	4050–3800	4230–3770	4040–3810	4160–3770	87.4	Organic temper. sherd 1
		2 O	3930–3670	3950–3650	3950–3720	3960–3660	104.3	Organic temper. sherd 2
		3 O	3910–3660	3950–3640	3950–3710	3960–3660	103.7	Organic temper. sherd 3
		5 M	4240–4040	4330–3980	4130–3970	4270–3950	72.8	Mineral temper. sherd 5
	end				3900–3590	3950–3110		

Table 10. *Results from modelling combined ^{14}C dates for each potsherd (OxCal v. 4.2.4). The fifth potsherd and the older sample (Ua-2382) from the fourth sherd were excluded from calculations.*

Phase	Boundary	Name	Unmodelled age with 68.2% confidence interval (BC)	Unmodelled age with 95.4% confidence interval (BC)	Modelled age with 68.2% confidence interval (BC)	Modelled age with 95.4% confidence interval (BC)	Agreement	Notes
Zedmar D potsherds	start				4060–3790	4440–3710		
		1 O	4050–3800	4230–3770	3980–3770	4040–3710	87.4	Organic temper. sherd 1
		2 O	3930–3670	3950–3650	3910–3690	3940–3660	104.3	Organic temper. sherd 2
		3 O	3910–3660	3950–3640	3910–3690	3940–3650	103.7	Organic temper. sherd 3
		Ua-2381	3700–3380	3800–3360	3890–3590	3940–3500	72.8	Mineral temper. sherd 4
	end				3780–3480	3930–3120		

the older layer from Zedmar A (4290/4090–4220/4060 calBC with 4240–4100 calBC for Bln-2162). The finishing range was taken after the sample from ending boundary for the second pottery model (3780–3480 calBC) after considering the end of the ZC phase onto Dudka site (3760–3530 calBC). Although there are not many issues certain in archaeology and radiocarbon dates modelling, the study presented above is still one of the most complex analyses of the ZC absolute chronology. There are some premises not to date the ZC material earlier than 4100 calBC, as combined age from pottery from Zedmar D or “Zedmar” layer from Dudka site. But with a possibly younger date than the layer from which the Gd-2593 sample (discussed above) was taken and due to a few parallel ways of interpreting radiocarbon datings from Zedmar D it is difficult to sustain.

4. CONCLUSIONS

There is some data which could clear the absolute chronology of the ZC up and some resolutions may be suggested. First, in the light of the results presented above, it is possible that the ZC could have lasted more briefly that it is usually stated. Nonetheless, due to the lack of dating materials and other methods of absolute age estimation, the long chronology of studied materials cannot be validated yet. There is also an option that some assemblages were misread or some stratigraphical records were incorrectly interpreted, in which case archaeologists should not consider the Zedmar materials as a separate archaeological culture, but rather as a local group of a larger structure. Then the question would be of which one.

As mentioned in the introduction, the ZC materials are characterised by a significant degree of syncretism and incorporating them into, say, Narva or Neman cultures is a matter of discussion among archaeologist from many countries. It can be said that it could be recognised as a distinctive feature of the ZC. For now, the first stated solution (the short chronology) seems to be more credible. With such an approach the ZC duration is closing between 4240–3480 calBC. Maybe a merged study with a more detailed look into archaeological assemblages of synchronic cultures could be more productive. However, subneolithic materials from the neighbouring area are poorly dated, so referring to them is even more difficult.

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