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CONTENTS

Editor's Foreword

This volume of the *Baltic Pontic Studies* focuses on the results of the research carried out so far into the absolute (radiocarbon) chronology of the area lying between the Vistula and Dnieper or the bio-cultural borderland between the West and East of Europe. Absolute chronology is treated here both as a research goal and fundamental premise in the broader studies of the chronometric and development synchronization of "borderland" cultural systems. In a series of articles devoted to individual taxa a considerable number of new ^{14}C dates have been compared. The dates concern source materials that have been chosen from the point of view of their representativeness and chronometric value ("short-lived" materials were preferred to minimize a potential error). The vast majority of analyses were purposefully made in the same ^{14}C laboratory of the *State Scientific Center of Environmental Radiogeochemistry of Ukrainian Academy of Sciences* in Kiev taking advantage of funds generously provided by the *Polish Committee for Scientific Research*.

The volume devoted to the "dark" section of the "borderland" history (3150--1850 BC) is the first but not the last publication on the broader issues mentioned above that we intend to present in the near future.

Editorial comment

1. All dates in the B-PS are calibrated [see: Radiocarbon vol.28, 1986, and the next volumes]. Deviations from this rule will be point out in notes.
2. The names of the archaelogical cultures and sites are standarized to the English literature on the subject (e.g. M. Gimbutas, J. P. Mallory). In the case of a new term, the author's original name has been retained.
3. The spelling of names of localities having the rank of administrative centres follows official, state, English language cartographic publications (e.g. *Ukraine, scale 1 : 2 000 000*, Kiev: Mapa LTD, edition of 1996).

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Nikolay N. Kovalyukh, Sergey V. Nazarov

RADIOCARBON DATING CALIBRATION IN ARCHEOLOGICAL STUDIES

Reliable radiocarbon dating, which displays real historical events, is a top, which all geochronologists with archeologists are striving to. The ^{14}C dating due to the intricate work made by representatives of radiocarbon has nearly been idealized in recent years by raising it in the "absolute" rank. These successes were reached at the improvement (refinement) account of the calibration curves by radiocarbon, which were checked against dendrochronological dating. Building of lengths of sub--calibration curves had exactly reproduced a temporal interval of historical events under study. These studies in separate events have made it possible to receive radiocarbon dating, which had ±10-20 years' mistake.

These successes have forced to take a look in a different way at the chronology and life period of many cultures, which lived on the Eastern European territory during the Ages of Copper and Bronze. Many cultures had had a rather complex way from their spring up to the stopping the existence. Several cultures, which had much in common, now and then, were in contact and lived in parallel over a course of prolonged period. Subsequently they were transformed into a new united culture.

All these stages of separate culture development are possible to be study when leaning upon the exact, reliable radiocarbon dating.

Authors of given article are the representatives of an isotopic geochronology and they have their own sight for ^{14}C dating improvement.

It is necessary to pass a long devious road from a selected by archeologists sample to a radiocarbon dating to be get. And such a road cannot be always finished by the aim achievement. Only the implementation of serious statistics, ^{14}C dating seriated obtained, make it possible to consider realistically one or another chronological length for the culture under study.

A validity degree of radiocarbon dating, obtained from different materials has been considered in this article. Improvement of BP dating calibration programs and a comparison between them by data obtained allows eliminating such kinds of mistakes, which would disturb subsequently to produce correlation of radiocarbon dating that had been obtained by cultures from different regions.

Finally, the control between laboratories is precisely this one which allows to exclude all doubts and to refer with confidence to radiocarbon dating obtained, which occasionally can make a revolution in archeologists' opinions and which force to take a new glance for the history of our distant ancestors existence.

1. METHODOLOGY OF RADIOCARBON DATING CALIBRATION

Radiocarbon method was based on the suggestion of ^{14}C-isotope concentration constancy in the atmosphere. However, atmospheric radiocarbon concentration depends on the tension and directivities of the earth's magnetic field, cosmic factors and solar activity. The international project on calibration curve building by annual tree rings was created for the reason to fix these change.

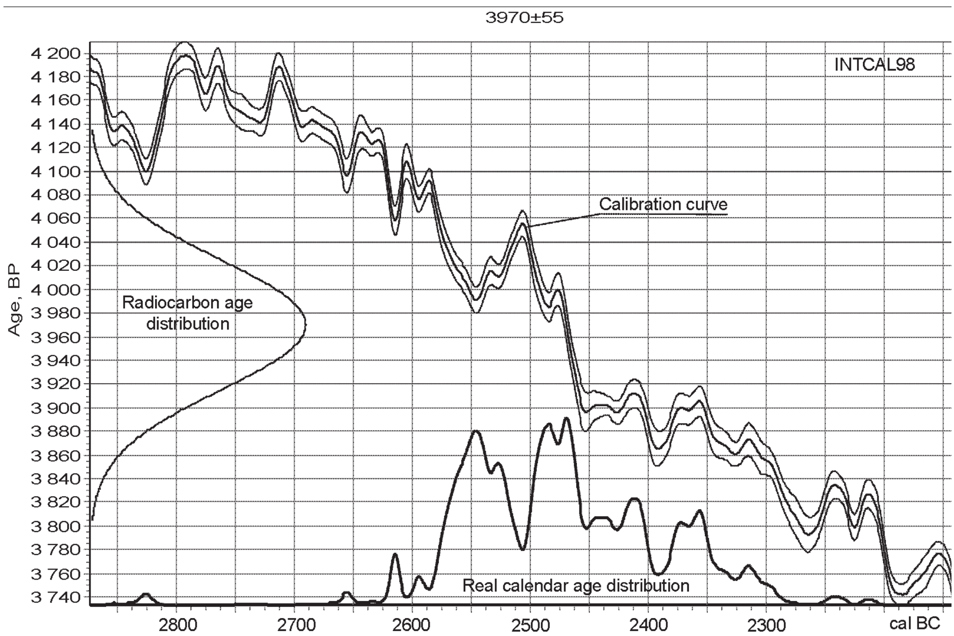

Fig. 1. Graphical presentation of calibration (Ki-6719)

Several unique buried trunks were selected with this aim to calculate the age by their well-saved annual rings. The concentrations of ^{14}C in separate annual tree rings and corals were determined, and the calibration curve up to 24 000 years (INTCAL98) was built [Stuiver, van der Plicht 1998].

The results of calibration are most are presented in the manner of intervals set that had been grouped for 1σ, 2σ and 3σ with corresponding dating probabilities of 63%, 95% and 99% within. Such kind of approach allows being orientated towards the real historical limits of dating. However, the application of intervals complicates understanding of results and does not present with a possibility for their statistical and chronological processing. That is why the necessity appeared of rounding off the calibration results and to present them in a dotted dating manner.

Graphical presentation of calibration is shown on the Fig. 1. Radiocarbon age Gaussian distribution when crossing with calibration curve forms a real historical age. It is possible to define probability of dating to be get in one or another interval by the given distribution - it will correspond to a figure area, which will be cut off by this interval. However an estimate of such probability is sufficiently complex computing process, so it would be simplest to calculate probability of getting a result into the forehand interval, and then to define subsequently this interval only. It was counted that probability of one mistake ($\pm\sigma$) to be brought into the interval is 63%, of duplicated mistake ($\pm 2\sigma$) - 95%, a tripled mistake ($\pm 3\sigma$) intervals are used more rarely, probability of finding wherein forms 99%. The employment of duplicated mistake intervals in practice may be sufficiently.

Principles of historical age determination are shown on the Fig. 2.

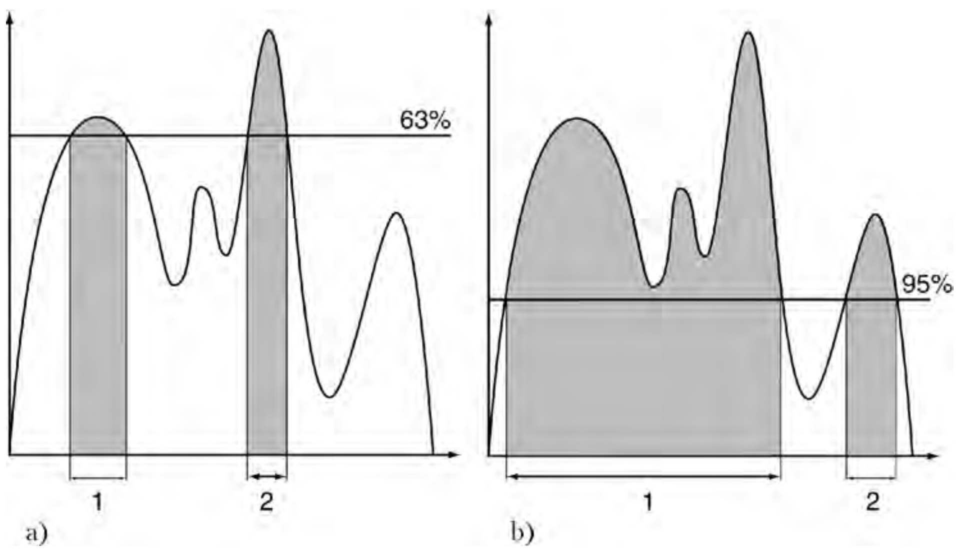

Fig. 2. Determination of calibration intervals: a) for 1δ, b) for 2δ

Calibration curve, as well as radiocarbon age has a measurement mistake. So, it is necessary at intersections of radiocarbon age distribution with calibration curve to take these mistakes into account. The variants of taking measurement mistake into account (σ dating) and the calibration curve mistakes (σ curve) are shown on the Fig. 3 [van der Plicht, Mook, Hasper 1987].

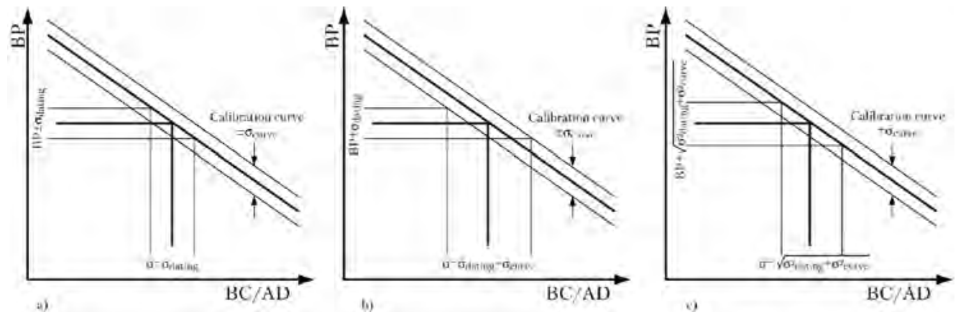

Fig. 3. Variants of taking measurement mistake into account and of calibration curve

The variant 1a does not take a calibration curve mistake into account that gives smaller sizes of calibration intervals as a result. The variant 1b does take both mistakes into account by their addition - it gives a maximum plausible calibration result at the big intervals of calibration. And finally, the variant 1c is the most correct consideration of mistake from the mathematical standpoint. If a calibration curve were presented as a direct line, the variant 1c would be ideal, however a calibration curve is not as such, so each of the presented method of mistakes consideration is meaningful in one or another situations.

Complexities of calibration interval results implementation for the chronological and statistical works have required an alternative view of these results. Certainly, the most demonstrative and suitable can be such a presentation of results as a dotted dating.

2. DOTTED DATING: ADVANTAGES AND DEFECTS

Bernhard Weninger was the first to come forward for this problem decision. He had elaborated a program that presents a result in one interval form; a probability of dating finding out in which is sufficiently great.

The difference between the concepts "dotted dating" and "single dating" if not great, and yet exists. Dotted dating characterizes a concrete dotted value of real calendar age with a divergence. Thus, it is possible to confirm that the most probable value of real historical age can form just the value of this dot. The age presentation in a single dating form is expressible by a dotted value with a divergence, however this dot is not the most probable value of real historical age. Historical age distribution is shown on the drawing 6 for Ki-7124 dating, the corresponding dotted dating presented by the "Ages" program, and the single dating obtained by the "CalPal" program.

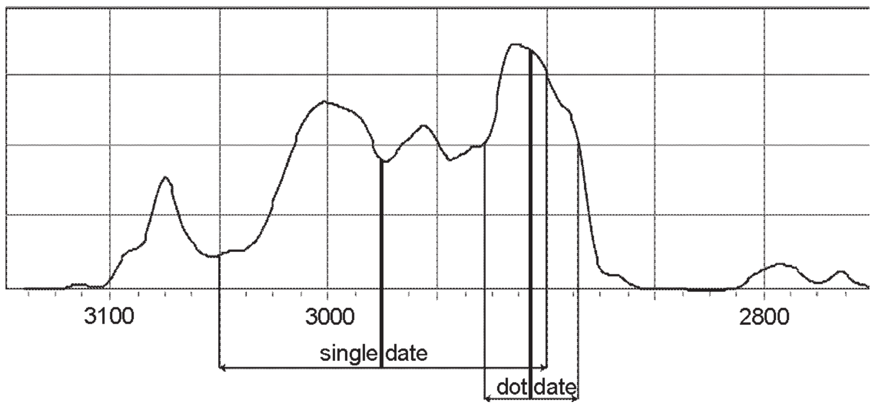

Fig. 4. Comparison between dotted and single dating

Each presentation has its own field of use - a single dating defines a range of dating coming, and it can be used for orientating within its staying limits; a dotted dating characterizes the most probable and narrow sufficiently interval of dating finding out.

Main defect of single dating is a possibility to define broad limits of result - they exceed as a rule the radiocarbon age initial divergences. Different probability of result for dating group is a defect of dotted dating.

3. MATERIALS FOR DATING AND RELIABILITY OF RADIOCARBON DATING OBTAINED

Materials for dating purpose within the range of reliability degree by the radiocarbon dating obtained can be aligned in the following sequence: large fossil bones → wood → organic remains of grasses → large coal → fossil soils → fine charcoal → small fossil bones → clamshells.

Bone material has the major use since it is the very reliable and numerous one when archeological excavations carried out under studies for dating. Calogen of fossil bones is subjected sometimes to a bacterial processing, and the isotopic age obtained under investigation of samples can be distorted as a result of biological fractionation. A correction for fractionation $\delta^{13}C$, which can be obtained by mass--spectrometric method, must be input for each sample with the goal of all distortions consideration for the age obtained.

The most reliable for radiocarbon dating are tubular bones of normal density, the least suitable are considered friable bones and brainpans which had been built from fine bone plates with friable and porous surface, as a rule.

Wood follows fossil bones within the range of materials safety. The mentioned one is often met at excavations. The reliable radiocarbon dating can be get from the wood samples when correct chemical training had been carried out. However the fact can be taken into consideration that the wood while keeping in the soil is subjected to decomposition, and in the most cases we can deal with the samples presenting a central part of a tree. In these cases dating are to be aged artificially for 50-150 years.

The examples of radiocarbon dating of Yamnaya culture (YC) monuments obtained from different material (tree, fossil bones) are presented in Tables 1 and 2.

Table 1

The results of the Yamnaya culture samples radiocarbon dating (fossil tree) of the Ukrainian territory

No.	Tie			Lab. Number	Age BP
	Location	Sample	Presented by		
1	Vidradne, Novyi Buh Distr., Mykolaiv Region	barrow 1, burial 21	O.G. Shaposhnikova	Ki-7070	3890±65
2	Vishneve, Tatarbunary Distr., Odesa Region	barrow 17, burial 38	L.V. Subbotin	Ki-7126	4105±65
3	Novoselitsa, Tatarbunary Distr., Odesa Region	barrow 19, burial 19	L.V. Subbotin	Ki-7127	4055±60
4	Novoselitsa, Tatarbunary Distr., Odesa Region	barrow 20, burial 8	L.V. Subbotin	Ki-7128	4005±50
5	Vinogradne, Tomakivka Distr., Zaporizhzhia Region	barrow 15, burial 5	V.V. Otroshchenko	Ki-7129	4145±55
6	Kremniovka, Volodarske Distr., Donetsk Region	barrow 6, burial 6	S.M. Bratchenko	Ki-7124	4325±60
7	Kremniovka, Volodarske Distr., Donetsk Region	barrow 6, burial 7	S.M. Bratchenko	Ki-7125	4365±55

Table 2

The results of Yamnaya culture samples radiocarbon dating (fossil bones) of Ukrainian territory

No.	Tie		Lab.	Age BP
	Location	Sample	Number	
1	Ordzhonikidze - 1997	b. 11, g. 90	Ki-6571a	4035±50
2	Ordzhonikidze - 1997	b. 11, g. 11	Ki-6572a	4005±55
3	Golovkovka	b. 6, g. 8	Ki-6719	3970±55
4	Golovkovka	b. 7, g. 4	Ki-6722	3980±60
5	Golovkovka	b. 11, g. 5	Ki-6723	4030±60
6	Golovkovka	b. 12, g. 3	Ki-6724	3950±50
7	Golovkovka	b. 5, g. 3	Ki-6730a	3925±55
8	Golovkovka	b. 5, g. 5	Ki-6731	4005±55
9	Protopopovka	b. 2, g. 2	Ki-6733	3945±50
10	Protopopovka	b. 2, g. 3	Ki-6734	3925±55

Diagram of comparison for calibrated radiocarbon dating obtained by wood and fossil bones (Table 1 and Table 2) is shown on the Fig. 5. From the data obtained one can see that radiocarbon dating presented by wood are more ancient. The earlier dating has been obtained, according to the diagram, for the «Kremniovka» monument - about 3 thousand BC years. However, one important point should be remembered, that we used to compare different monuments of YC, which are situated in different regions of Ukraine. That is why, this question requires an extended discussions for the final conclusions.

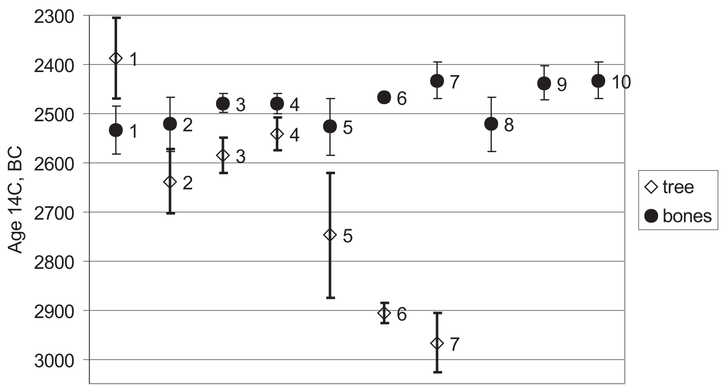

Fig. 5. Comparison of calibrated radiocarbon dating

Table 3

The results of interlaboratory control

No.	Sample	Kiev radiocarbon laboratory		Oxford radiocarbon laboratory	
		Lab. Number	Age ^{14}C, BP	Lab. Number	Age ^{14}C, BP
1	Nikolsky, grave 125	Ki-6603	6160±70	OXA-5029	6300±80
2	Yasinovatka, grave 45	Ki-6791	6305±80	OXA-6164	6360±75
3	Yasinovatka, grave 19	Ki-6788	6310±85	OXA-6165	6370±60
4	Vasilievka 5, grave 29	Ki-6776	6220±60	OXA-6198	6298±70
5	Vasilievka 5, grave 8	Ki-6777	6430±50	OXA-6171	6470±70
6	Marievka 5, grave 10	Ki-6781	7585±80	OXA-6200	7620±100
7	Marievka 5, grave 14	Ki-6780	7600±100	OXA-6269	7630±110

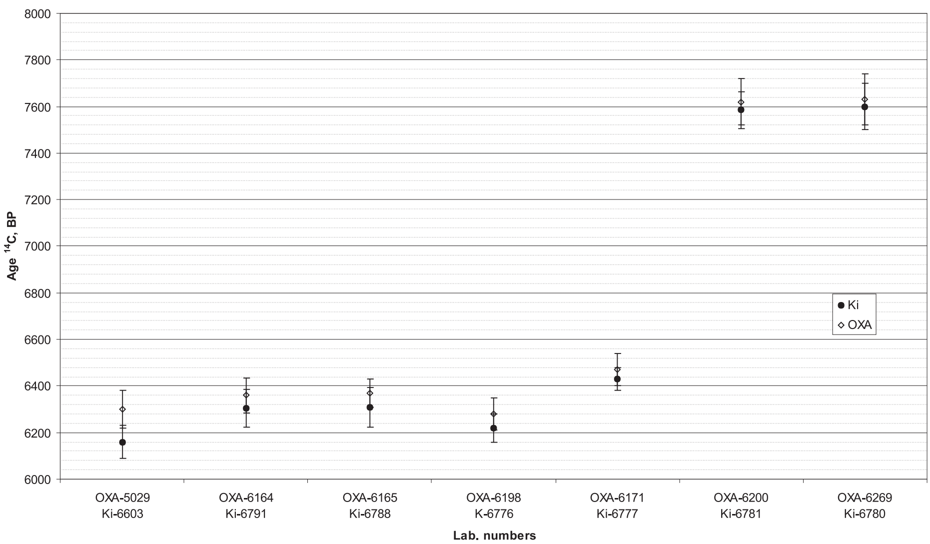

Fig. 6. Radiocarbon dating comparison

It is necessary also to consider a reliability degree of radiocarbon dating obtained by fine fragmental charcoal. As often happens, the archeologists at excavations find a body of fine fragmental charcoal in a cultural layer, which differs in later age from the monuments studied. Such kind of bodies are formed, as a rule, after large fires at the sacrifice of filling rodents and insects burrows with light charcoal transferred by winds and floods. So, it is preferable to use charred wood fragments when getting radiocarbon dating.

Interlaboratory control is one of number reliability and validity criteria for radiocarbon dating obtained as well. Laboratories participating in such a kind of control with a purpose of isotopic dating makes use samples with practically equal radiocarbon contents. There were presented fragments of men skeleton skulls for comparison by radiocarbon between laboratories. Materials for dating had been taken from the different Neolithic burial-mounds, situated through the Ukrainian territory. These materials have been presented to Kiev and Oxford radiocarbon laboratories by prof. D.Y. Telegin. Results of radiocarbon dating are shown in the Table 3. The analysis of resulting data exhibited in the Fig. 6, points to the fact of good coordination between dating obtained by precisely these samples in different laboratories.

4. COMPUTER-AIDED MANUFACTURING OF CALIBRATION

There are some programs for radiocarbon dating calibration. A more widespread amongst them are the following: Groningen radiocarbon calibration program (“Cal25”) designed by Johannes van der Plicht at the Center of Isotopic Studies of Groningen University [van der Plicht 1993], Oxford calibration program (“OxCal”) designed by Christopher B. Ramsey at Radiocarbon Department of Oxford University [Ramsey 1995] and “CalPal” calibration program of Bernhard Weninger developed in the radiocarbon laboratory of Cologne University [Weninger 1986].

Radiocarbon dating calibration can also be executed by Kiev radiocarbon calibration program “Ages”, designed in the radiocarbon laboratory at the State Scientific Center of Environmental Radiogeochemistry of NAN of Ukraine [Nazarov, Kovalyukh 1999]. The program is functioning by IBM PC joint computers under MS Windows 95 operating system management. Main advantages of the program are convenient way in use, interface for lots of languages and possibility for calibration results to be exported in the most widespread graphic formats of files.

The “Ages” program had been written on C++ language and was executed in accordance with Windows 95 standards. All the program functions provided are available through the main menu, but the most abundant ones have been brought to the panel of quick access.

For purpose of dating calibration it is necessary and sufficiently to indicate its radiocarbon age in BP$\pm\sigma$ form. The program allows if needed to add some additional information of dating laboratory number, tie, owner of sample etc. When creating a list of samples it is possible to indicate the sample’s name and author. All the data input are stored in the file, which will also be available for a further use on any computer, where the “Ages” program is installed.

Inasmuch as there is sufficiently great amount of calibration curves up to the present day, the program gives a chance to choose one of the curves represented in the form of separate files.

Calibration curve, practically, is presented by a set of dots put down 10-20 years distant of time lapse from one dot to another. Cubic interpolation is used in the program for the curve presentation as uninterrupted curve. Function form between two dots is determined by four dots around ones [Reinsch 1967]. The estimation of radiocarbon age Gaussian distribution is executed within 3σ limits.

There were four programs to be used in order to compare the calibration results: “Cal25”, “OxCal”, “CalPal” and “Ages”. The parameters of primary importance comparison are certainly the results of calibration. The programs “Cal25” and “OxCal” present the results in an interval type, the single dating program is a result of “CalPal” calibration program, the “Ages” program presents a results just as in an interval so in a dotted dating. The calibration results are provided in the Table 4.

Table 4

The results of radiocarbon dating calibration

Lab. number	Cal25	OxCal	CalPal	Ages	
				dot	intervals
Ki-7070	1σ 2465-2289 2σ 2559-2535 2531-2523 2495-2197 2163-2145	1σ 2470-2280 2σ 2560-2520 2500-2190 2170-2140	2355±95	2388±82	1σ 2470-2306 2σ 2572-2515 2500-2271 2257-2227 2223-2204
Ki-7126	1σ 2861-2811 2755-2723 2701-2575 2511-2505 2σ 2877-2555 2539-2495	1σ 2860-2810 2760-2720 2700-2570 2510-2500 2σ 2880-2490	2700±120	2638±65	1σ 2862-2808 2777-2773 2758-2720 2704-2573 2514-2501 2σ 2880-2471
Ki-7127	1σ 2835-2817 2663-2647 2625-2487 2485-2471 2σ 2865-2807 2781-2771 2759-2717 2707-2463	1σ 2840-2810 2670-2470 2σ 2870-2460	2640±130	2586±36	1σ 2832-2820 2661-2650 2623-2550 2542-2491 2479-2474 2σ 2863-2807 2779-2771 2759-2719 2706-2464
Ki-7128	1σ 2575-2511	1σ 2580-2460	2530±60	2542±34	1σ 2576-2508

Lab. number	Cal25	OxCal	CalPal	Ages	
				dot	intervals
	2505-2467 2σ 2835-2817 2663-2649 2625-2401 2379-2349	2σ 2840-2810 2670-2400 2380-2340			2504-2468 2σ 2828-2823 2658-2652 2622-2607 2602-2458 2419-2406 2358-2356
Ki-7129	1σ 2869-2831 2821-2805 2783-2769 2761-2717 2709-2661 2651-2623 2605-2603 2σ 2881-2617 2613-2577	1σ 2870-2600 2σ 2880-2570	2730±100	2748±127	1σ 2876-2621 2608-2599 2587-2585 2σ 2883-2571 2516-2500
Ki-7124	1σ 3019-2977 2971-2945 2939-2885 2σ 3261-3243 3099-2865 2807-2781 2771-2761 2719-2707	1σ 3020-2880 2σ 3300-2700	2975±75	2906±20	1σ 3014-2981 2963-2951 2927-2886 2σ 3094-2878
Ki-7125	1σ 3081-3069 3027-2909 2σ 3307-3291 3289-3271 3265-3239 3169-3161 3101-2883	1σ 3080-3060 3030-2900 2σ 3310-3230 3110-2880	3010±80	2967±60	1σ 3081-3068 3028-2907 2σ 3260-3241 3099-2884
Ki-6571a	1σ 2619-2609 2597-2591 2583-2487 2485-2471 2σ 2857-2813 2735-2725 2697-2463	1σ 2620-2470 2σ 2860-2810 2750-2720 2700-2460	2580±80	2534±48	1σ 2619-2610 2597-2590 2582-2486 2484-2472 2σ 2854-2851 2841-2816 2671-2464
Ki-6572a	1σ 2617-2613 2579-2465 2σ 2853-2849 2841-2815 2669-2397 2385-2345	1σ 2620-2610 2580-2460 2σ 2900-2800 2700-2300	2540±70	2522±55	1σ 2616-2614 2577-2467 2σ 2832-2820 2661-2650 2623-2403 2376-2352

Lab. number	Cal25	OxCal	CalPal	Ages	
				dot	intervals
Ki-6719	1σ 2573-2515 2501-2455 2447-2433 2423-2403 2373-2371 2363-2353 2σ 2621-2609 2597-2589 2583-2297	1σ 2580-2400 2380-2350 2σ 2620-2290	2475±85	2479±19	1σ 2566-2520 2498-2460 2σ 2619-2611 2596-2592 2581-2306
Ki-6722	1σ 2577-2455 2445-2435 2421-2403 2363-2353 2σ 2833-2819 2661-2649 2623-2293	1σ 2580-2400 2370-2350 2σ 2850-2800 2700-2250	2490±90	2480±20	1σ 2572-2515 2500-2461 2σ 2826-2826 2657-2653 2621-2608 2601-2306
Ki-6723	1σ 2657-2653 2621-2607 2601-2467 2σ 2861-2811 2755-2721 2703-2455 2449-2431 2423-2403 2375-2369 2365-2353	1σ 2660-2650 2630-2460 2σ 2900-2350	2590±100	2527±57	1σ 2620-2609 2598-2588 2584-2470 2σ 2858-2812 2744-2724 2698-2459 2416-2409
Ki-6724	1σ 2557-2537 2527-2525 2495-2401 2379-2349 2σ 2575-2511 2503-2295	1σ 2560-2520 2500-2400 2380-2340 2σ 2580-2290	2450±90	2466±10	1σ 2551-2541 2491-2478 2475-2456 2447-2433 2421-2404 2362-2353 2σ 2575-2511 2503-2295
Ki-6730a	1σ 2471-2331 2323-2309 2σ 2571-2517 2499-2281 2251-2233 2219-2207	1σ 2480-2300 2σ 2580-2200	2410±80	2433±37	1σ 2470-2396 2386-2339 2318-2312 2σ 2570-2517 2499-2280 2251-2231 2219-2207
Ki-6731	1σ 2617-2613 2579-2465 2σ 2853-2849	1σ 2620-2610 2580-2460 2σ 2900-2800	2540±70	2522±55	1σ 2616-2614 2577-2467 2σ 2832-2820

Lab. number	Cal25	OxCal	CalPal	Ages	
				dot	intervals
	2841-2815 2669-2397 2385-2345	2700-2300			2661-2650 2623-2403 2376-2352
Ki-6733	1σ 2555-2539 2495-2399 2381-2347 2σ 2575-2513 2503-2293	1σ 2560-2530 2500-2340 2σ 2580-2290	2445±85	2438±35	1σ 2549-2543 2490-2480 2473-2403 2376-2352 2σ 2574-2513 2501-2293
Ki-6734	1σ 2471-2331 2323-2309 2σ 2571-2517 2499-2281 2251-2233 2219-2207	1σ 2480-2300 2σ 2580-2200	2410±80	2433±37	1σ 2470-2396 2386-2339 2318-2312 2σ 2570-2517 2499-2280 2251-2231 2219-2207

Just the same calibration curve - INTCAL98 was used when calibration. Discrepancy between these calibration results are explained by the accuracy of calculations applied in the program and, certainly, by the method of calibration curve and radiocarbon dating errors consideration [van der Plicht, Mook 1987].

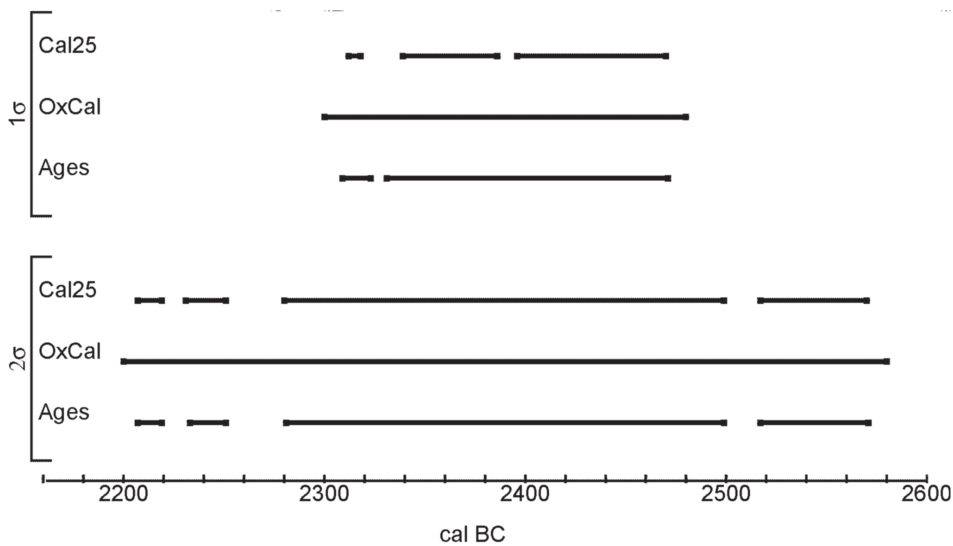

Fig. 7. The results of calibration graphic comparison (Ki-6734)

Fig. 7 illustrates a graphic comparison of calibration interval results for more pictorial visualization of the results.

Comparison of calibration results is the very important question when the programs are compared, however, a list of additional functions provided by the programs, comfort of input-output data, etc. are to be necessary taken into account. The programs “Cal25” and “CalPal” run on under MS DOS operating system, that is why an export of results to another applications is obstructed. “OxCal” and “Ages” are devoid such a defect - both of them run on under MS Windows operating system and have the export means of results.

There is more specific attention paid for exporting of graphical results to the vector formats in “Ages” program, that allows editing easy later on. Suitable print functions allow to make printout easily of both single dating calibration results and dating groups results tables.

5. CONTRIBUTION TO THE YAMNAYA CULTURE CHRONOLOGY

We used radiocarbon dating obtained as to YC of Ukrainian steppe and partially forest - steppe zones for chronological analysis. Full description of YC monuments pointed in the Table 1 and Table 2 is illustrated in the published work of D.Y. Telegin [Telegin 1977].

As for climate-chronological aspect the YC on the territory of Ukraine came into existence on the mark of Atlantic and Subboreal periods changing, about 3200--2900 years BC. Then more severe subboreal climate gave way to warm climate of Atlantic period. The “Kremniovka” monument (it was among those with dating carried out) which was existing in 2970-2900 years BC belongs, by isotopic data, to the monuments of Early YC. Almost without exception all the monuments with dating carried out refer to the Late YC age. A climatic optimum appears in that time (2800-2400 years BC), which promotes demography burst and blossoming forth of YC. Cold and humid climate of Early Subboreal gave way to warm and temperate dry climate - the optimum conditions for life appear - high grasses in steppes, broad--leaved forests in partially wooden steppe zone. A large number of radiocarbon dating, which characterize the main stage of the Late YC development within 2600--2400 years BC chronological limits.

We can conclude by isotopic chronological investigations that YC existed about one thousand years on the territory of Ukraine since the time of its incipience up to its change by Catacomb culture and other ones.

CONCLUSIONS

a. Radiocarbon dating calibration is a complex mathematical process of natural changes and measurements faults consideration in radiocarbon age finding out, however this process is required for the real history age estimation. Ambiguous approach for these factors consideration explains a difference between calibration results obtained by different calibration programs.
b. Dotted dating account applied in the program is not ideal, and it requires a further study.
c. Dotted data obtained are appropriate in the case of using them in a chronological and a statistic information, however the employment of intervals which display all the possible confines of dating finding out would be more correctly for the sample historical age dating determination.
d. Tubular fossil bones are the best archeological materials so that the plausible data can be obtained by radiocarbon.
e. Essentially all radiocarbon dating presented of YC through the territory of Ukraine are within the subboreal climatic optimum (4200-3900 BP).

Translated by authors

ABBREVIATIONS

AO	–	Arkheologicheskiye otkrytya, Moskva.
AJA	–	American Journal of Archaeology, New York.
BPS	–	Baltic-Pontic Studies, Poznań.
EA	–	Eurasia Antiqua, Berlin.
FPP	–	Folia Praehistorica Posnaniensia, Poznań.
KSIA	–	Kratkiye soobshcheniya Instituta Arkheologii, Moskva.
KSIA AN USSR	–	Kratkiye soobshcheniya Instituta Arkheologii AN USSR, Kiev.
KSIIMK	–	Kratkiye soobshcheniya Instituta Istorii Materialnoy kultury, Moskva.
KSOGAM	–	Kratkie Soobshcheniya Odesskogo Gosudarstvennogo Arkheologicheskogo Muzeya, Odessa.
MIA	–	Materialy i issledovaniya po arkheologii, Moskva.
NA IA NANU	–	Naukovy Arkhiv Instituta Arkheologii Nacionalnoi Akademii Nauk Ukrainu, Kiev.
SA	–	Sovetskaya Arkheologia, Moskva.
SpA	–	Sprawozdania Archeologiczne, Kraków.
ZFA	–	Zeitschrift für Archäologie, Berlin.

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