RADIOCARBON, Vol 46, Nr 2, 2004, p 943–948

THE COMPARISON OF ^{14}C WIGGLE-MATCHING RESULTS FOR THE 'FLOATING' TREE-RING CHRONOLOGY OF THE ULANDRYK-4 BURIAL GROUND (ALTAI MOUNTAINS, SIBERIA)

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ABSTRACT. Two independent ^{14}C data sets of 10 tree-ring samples from the longest master chronology of the Pazyryk cultural complex were obtained and wiggle-matched to the absolute timescale. The results show very good agreement, within 10–15 calendar yr. The Ulandryk-4 burial ground (mound 1) was dated to about 320–310 cal BC, and this is consistent with wiggle-matching of the Pazyryk burial ground date series.

INTRODUCTION

Recent dendrochronological study of wood from the Iron Age Pazyryk cultural complex in the Altai Mountains, southern Siberia, allow constructing a 415-yr-long "floating" master chronology (Seifert and Slusarenko 1996, 2000). The high-precision ^{14}C dating and consequent wiggle-matching of the results obtained were performed to determine the calendar age of the floating master chronology in particular, and of the Pazyryk complex in general (Slusarenko et al. 2001; Dergachev et al. 2001; Slusarenko et al., forthcoming; Hajdas et al., forthcoming). The longest single tree-ring sequence from the Ulandryk-4 burial ground (which covers 363 yr) was the main object of research. Two independent ^{14}C data sets were obtained, and the results were wiggle-matched to the absolute timescale. In this paper, we present the comparison of the results of parallel ^{14}C dating and wiggle-matching of the same tree-ring sequence.

MATERIALS AND METHODS

The single Siberian larch (*Larix sibirica* Ledebour) dendro sample #19116 (363 tree rings) from burial mound 1, Ulandryk-4 burial ground at the Pazyryk Early Iron Age complex (Altai Mountains, southern Siberia, Russia; 49°42′N latitude, 89°08′E longitude; elevation about 2150 m asl), was used for key study (Figure 1). Mound 1 represents a stone burrow 13 m in diameter, under which a grave pit of 3.6 × 2.85 × 3.05 m was excavated. A rectangular burial chamber of larch logs was found at the bottom of the grave pit (Kubarev 1987). The chamber contains a human skeleton and it was filled with ice; the preservation of archaeological wood is very good.

Sample #19116 was subdivided into 10 annual tree-ring (decadal) sub-samples. Thirty-five consequent sub-samples (U1–U35; tree rings nr 1–350) were ^{14}C dated at the NSF-Arizona AMS facility (University of Arizona, Tucson, Arizona, USA; Lab code AA-). Eighteen sub-samples (Ul1–Ul18), started from tree-ring nr 13 and ended at nr 363, with 10 tree-ring gaps between each sub-sample, were ^{14}C dated at the ETH/AMS facility (Zürich, Switzerland; Lab code ETH-) (Table 1). Thus, 2

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Proceedings of the 18th International Radiocarbon Conference, edited by N Beavan Athfield and R J Sparks
RADIOCARBON, Vol 46, Nr 2, 2004, p 943–948

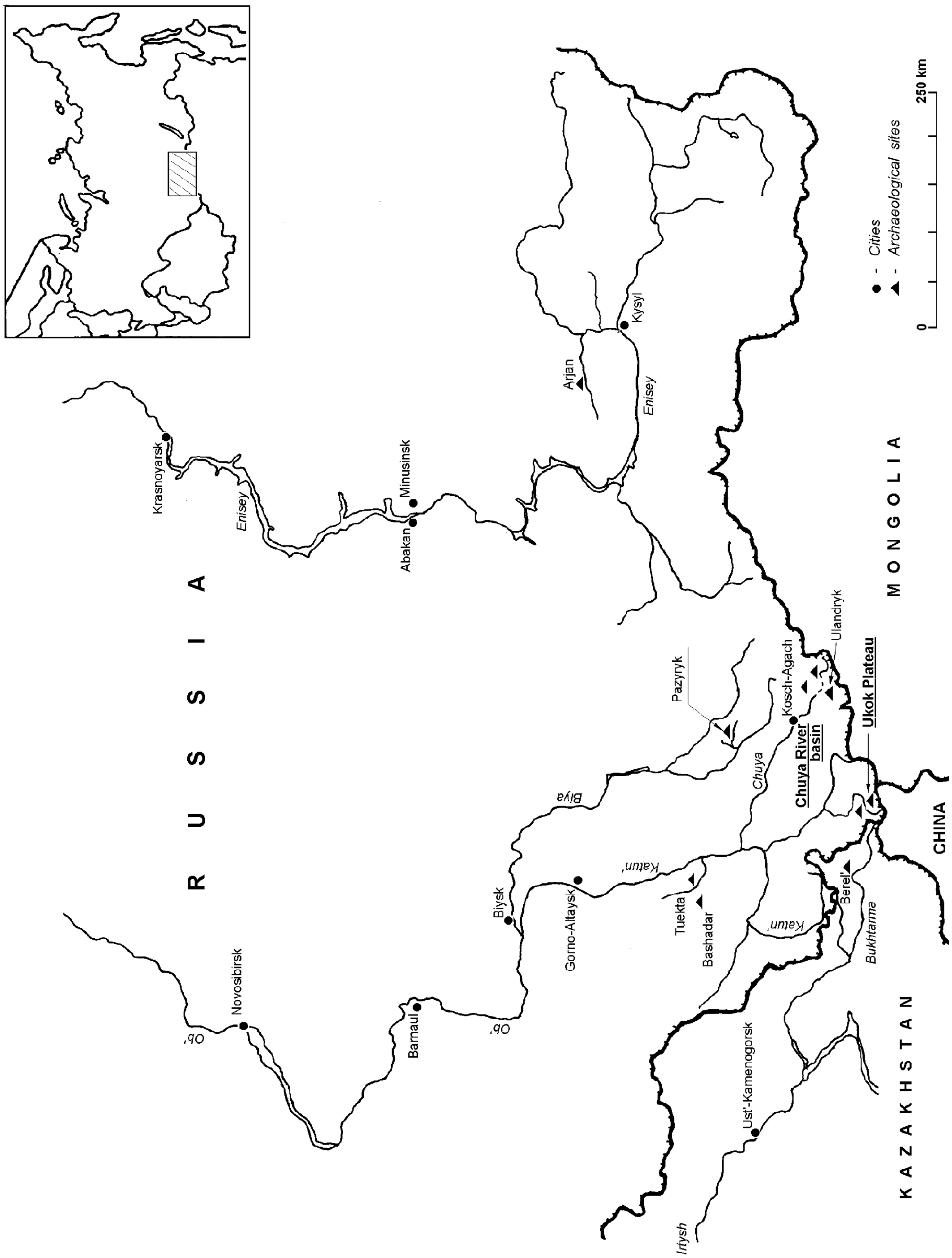

Figure 1 Location of the Ulandryk burial mound and other important Early Iron Age complexes in the Altai Mountains

Table 1 The results of AMS ^{14}C dating of decadal tree-ring samples from Ulandryk-4 (dendro-sample #19116).

Sub-sample (AA-)	^{14}C date	Sub-sample (ETH-)	^{14}C date
U-1 (rings #1–10), 37585	2540 ± 19		
U-2 (rings #11–20), 37586	2440 ± 22	Ul-18 (rings #13–23), 19861[a]	2345 ± 25
U-3 (rings #21–30), 37587	2470 ± 19		
U-4 (rings #31–40), 37588	2470 ± 22	Ul-17 (rings #33–43), 19860[a]	2410 ± 25
U-5 (rings #41–50), 37589	2500 ± 18		
U-6 (rings #51–60), 37590	2490 ± 18	Ul-16 (rings #53–63), 19859	2550 ± 50
U-7 (rings #61–70), 37591	2510 ± 22		
U-8 (rings #71–80), 37592	2525 ± 19	Ul-15 (rings #73–83), 19858	2530 ± 35
U-9 (rings #81–90), 37593	2505 ± 19		
U-10 (rings #91–100), 37594	2520 ± 20	Ul-14 (rings #93–103), 19857	2515 ± 35
U-11 (rings #101–110), 37595	2490 ± 20		
U-12 (rings #111–120), 37596	2480 ± 25	Ul-13 (rings #113–123), 19856	2455 ± 35
U-13 (rings #121–130), 37597	2480 ± 19		
U-14 (rings #131–140), 37598	2435 ± 39	Ul-12 (rings #133–143), 19855	2410 ± 45
U-15 (rings #141–150), 37599	2440 ± 22		
U-16 (rings #151–160), 37600	2470 ± 19	Ul-11 (rings #153–163), 19854	2450 ± 50
U-17 (rings #161–170), 37601	2470 ± 19		
U-18 (rings #171–180), 37602	2470 ± 19	Ul-10 (rings #173–183), 19853	2410 ± 50
U-19 (rings #181–190), 37641	2460 ± 36		
U-20 (rings #191–200), 37642	2410 ± 26	Ul-9 (rings #193–203), 19852	2490 ± 35
U-21 (rings #201–210), 37643	2460 ± 26		
U-22 (rings #211–220), 37644	2435 ± 26	Ul-8 (rings #213–223), 19851	2465 ± 40
U-23 (rings #221–230), 37645	2470 ± 26		
U-24 (rings #231–240), 37646	2395 ± 26	Ul-7 (rings #233–243), 19850	2450 ± 35
U-25 (rings #241–250), 37647	2435 ± 58		
U-26 (rings #251–260), 37648	2450 ± 41	Ul-6 (rings #253–263), 19849	2410 ± 35
U-27 (rings #261–270), 37649	2340 ± 41		
U-28 (rings #271–280), 37650	2270 ± 40	Ul-5 (rings #273–283), 19848	2330 ± 35
U-29 (rings #281–290), 37651	2260 ± 40		
U-30 (rings #291–300), 37652	2280 ± 46	Ul-4 (rings #293–303), 19847	2295 ± 35
U-31 (rings #301–310), 37653	2280 ± 36		
U-32 (rings #311–320), 37654	2205 ± 34	Ul-3 (rings #313–323), 19846	2230 ± 35
U-33 (rings #321–330), 37655	2230 ± 34		
U-34 (rings #331–340), 37656	2260 ± 38	Ul-2 (rings #333–343), 19845	2170 ± 25
U-35 (rings #341–350), 37657	2310 ± 43		
		Ul-1 (rings #353–363), 19844	2215 ± 25

[a]Outliers.

^{14}C decadal data sets were produced for this dendrochronology, which allow a rare chance to compare the results of the wiggle-matching for both data sets.

The Bayesian approach to calibration (Christen and Litton 1995) was used to wiggle-match the Tucson data set, with the help of *Bwigg* software (for more details, see the *Bwigg* web page, http://www.cimat.mx/Bwigg). The χ^2 method was applied to find the best fit to the INTCAL98 curve for the Zürich data set.

RESULTS AND DISCUSSION

The Bayesian approach allows to wiggle-match the Tucson decadal date series (Figure 2). The best match of the end of sequence, including additional 13 tree rings which were not ^{14}C dated, is 2261 cal BP (i.e. ~312 BC) (Slusarenko et al., forthcoming). The interval 2271–2253 cal BP accumulates 96% of the posterior probability for the match. The χ^2 wiggle-match placed the absolute age of the last preserved ring of the construction timber from $312^{+13}/_{-21}$ BC (Figure 3) (Hajdas et al., forthcoming). This is based on the fit which does not include the 2 apparent outliers (ETH-19860 and 19861, Table 1). Thus, both data sets coincide in their matches within some 10–15 yr.

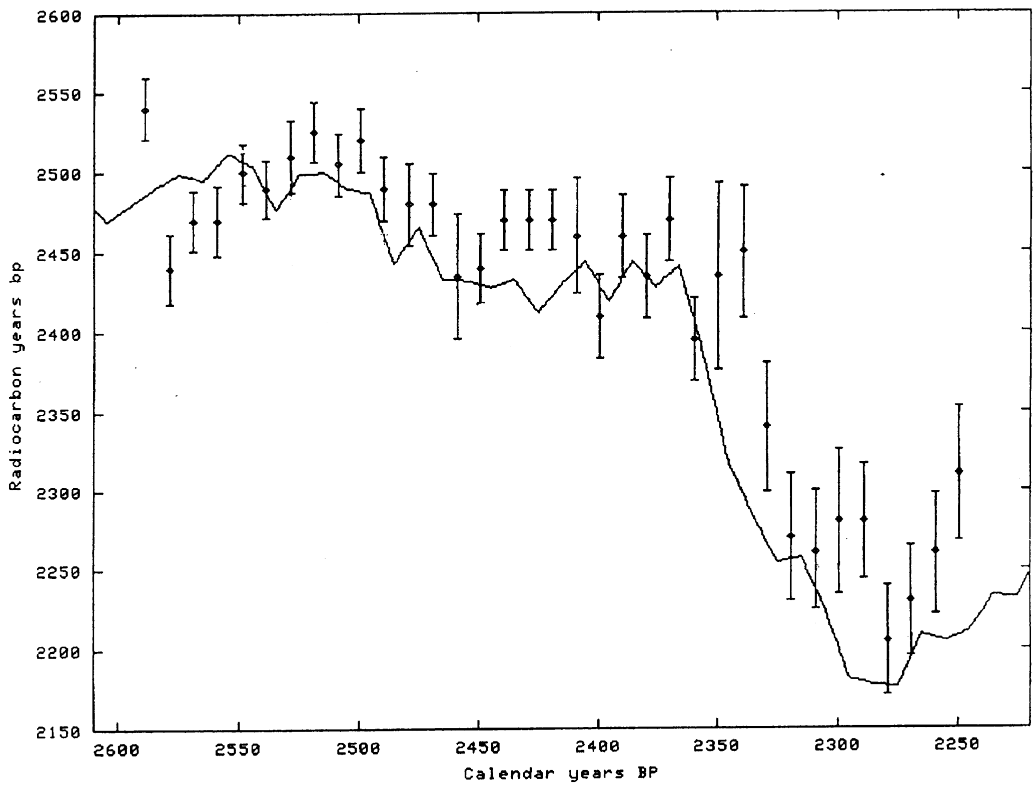

Figure 2 Tucson decadal data set for the Ulandryk-4 series as compared with the INTCAL98 calibration curve

Although it appears that the ^{14}C ages of the 2 earliest tree-ring sub-samples in the Zürich date series are too young when compared with the rest of dates, the repeat measurements on these samples confirm the younger ages, and these are, therefore, included in the calculated mean values (Table 1). We have no explanation for these unexpected ages in comparison with the Arizona date series (AA-37586 and 37588, Table 1); new analyses may be useful to explain them. However, these 2 points have no influence on the final dating result, except for the numeric χ^2 value and overall dating error. If the 2 outliers are included, the dating error is +37/–30 yr, and if rejected, +13/–21 yr (Hajdas et. al., forthcoming).

^{14}C dating for the other key dendroscale, derived from the Pazyryk burial ground, kurgan 2, was performed in 3 different laboratories (St. Petersburg, Zürich, and Belfast). The wiggle-matching of these date series show that the best match is at about 300–290 BC (Dergachev et al. 2001:423;

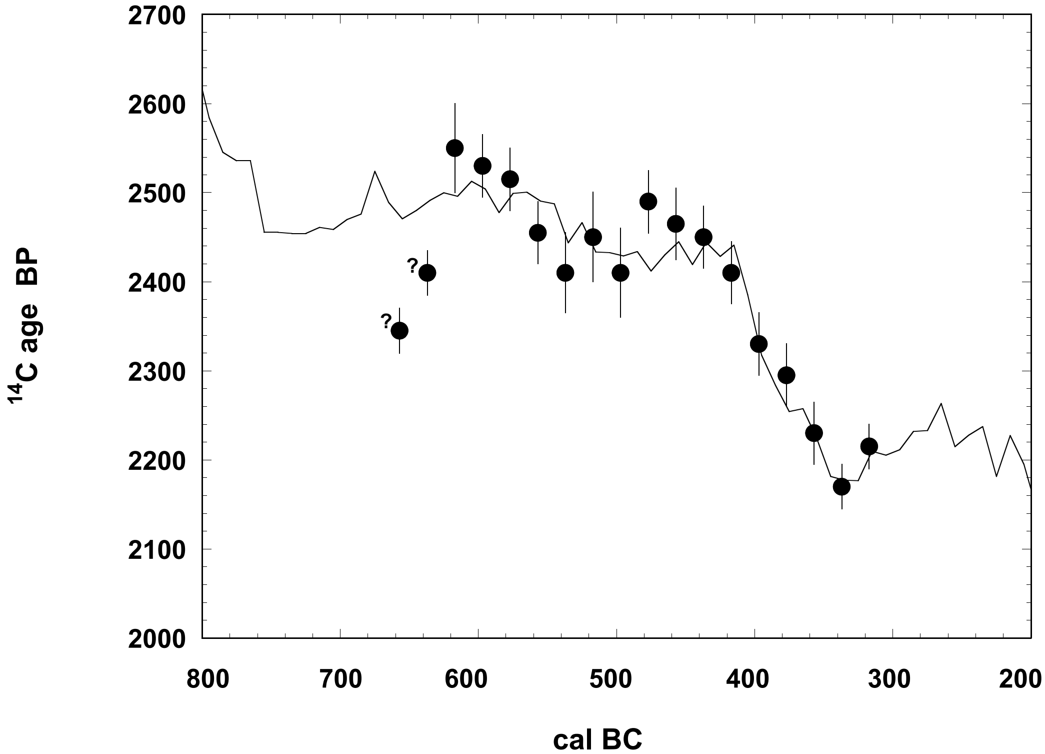

Figure 3 The Zürich decadal data set for the Ulandryk-4 series; the background is the INTCAL98 calibration curve (2 outliers are not included in the fit).

Vasiliev et al. 2001). This is based on a χ^2 fit of the ^{14}C ages previously published by Zaitseva et al. (1998). This result is very consistent with the best matches for the Ulandryk-4 decadal data series. Also, archaeologists who recently excavated the series of the Pazyryk culture burials in southern Altai Mountains, support the age determination of the Pazyryk sites as the end of the 4th to the first part of the 3rd centuries BC (Polos'mak 2001). Therefore, it seems reasonable to assume that the absolute age of the Pazyryk cultural complex in the Altai Mountains is now well established.

CONCLUSION

Two independent data sets, processed by 2 different techniques (Bayesian statistics and χ^2 method), allow us to document firmly the timing of the Pazyryk culture burials in the Altai Mountains, generally dated to the 4th–3rd centuries BC. More research is necessary to establish the calendar chronology of the ancient Bronze and Early Iron Age cultures in southern Siberia and Inner Asia with the help of precise ^{14}C dating and wiggle-matching of the date series. The Altai Mountains are the key region for dendrochronological and ^{14}C studies of archaeological wood.

ACKNOWLEDGEMENTS

We are grateful to colleagues who provided support for this study, Drs A J T Jull and G S Burr. This research was supported in part by grants from the Russian RFFI (00-06-80199) and US NSF (EAR 97-30699).

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