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FLOATING LARCH TREE-RING CHRONOLOGIES FROM ARCHAEOLOGICAL TIMBERS IN THE RUSSIAN ALTAI BETWEEN ABOUT 800 BC AND AD 800

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ABSTRACT. We obtained over 200 archaeological wood specimens from the southeastern part of the Altai Mountains (Russia) to establish accurate calendar dates of the timbers using both radiocarbon and tree-ring analyses. Most timbers came from small and elite tombs of the Pazyryk culture (Siberian Scythians of the Iron Age period). Timbers from Hun-Sarmatian and Turk times (1st millennium AD) were studied for the first time. Three floating tree-ring width chronologies of larch (*Larix sibirica*) with lengths of 486 yr to 144 yr were developed from the tree-ring data. Tree rings of the composite 486-yr chronology of the Pazyryk culture represent the regional scale of Altai tree-ring width variability between about 720–240 BC. The composite chronology dates the earliest construction of Pazyryk culture tombs to ~320 BC (ordinary tombs) and the latest ones at 240 BC (Pazyryk noble tomb #5). The composite chronology might be used for tree-ring dating wood from Scythian tombs in the region. It will also help confirm the precision of ^{14}C dating of the Scythian tombs around the Hallstatt plateau of ^{14}C calibration curves. We developed a 110-yr decadal ^{14}C sequence from the Kurayka site that dates Kok-Pash culture timbers back to cal AD 240 (Hun-Sarmatian period). ^{14}C dates of wooden poles from 3 sites of Turk stone enclosures suggested wood cutting dates between cal AD 470 and 830. The results demonstrate that crossdating tree rings along with ^{14}C dating of crossdated rings provide the most reliable and highest precision dates for these archaeological sites.

INTRODUCTION

Recent results on radiocarbon wiggle-matching of floating tree-ring series from 2 tombs of the Pazyryk archaeological culture (Iron Age) in the Altai Mountains have significantly advanced the precision of calendar dating Pazyryk sites (Vasiliev et al. 2001; Sljusarenko et al. 2004). Less successful attempts have also been made to crossdate single tree-ring width series from various key tombs to identify independently the time elapsed between the construction of various tombs (Marsadolov 1996; Sljusarenko 2000). The overall progress on the Pazyryk dating suggests that the known Pazyryk culture noble tombs were developed from 325 to 250 cal BC (Zaitseva et al. 2005), which is about 200 yr younger than previously thought. These principal dates have tremendous importance for the history of Scythian nomads in the steppes of Iron Age Eurasia. Nevertheless, more reliably dated field evidence is needed. The ^{14}C chronology of the Pazyryk tombs does not provide the high temporal resolution that might enhance comparison with the historical archives of Western and Chinese civilizations. Dendrochronology refines the temporal resolution of dates from ^{14}C wiggles because decadal tree rings can be subsampled. Furthermore, a tree-ring record might serve as a natural archive, documenting reliably and independently the times of tomb construction through tree-ring crossdating.

Naturally, merging long-term tree-ring chronologies from living tree-stands with floating tree-ring chronologies from archaeological timbers is a technique that might provide absolute calendar dates for the chronology of the Siberian Scythians. Fortunately for Siberian dendrochronology, larch is commonly used in burial constructions of the past and the remains are often well preserved. Larch timbers have been repeatedly reported from archaeological excavations of monuments from the Hun-Sarmatian and Turk periods in the Russian Altai (Kubarev 1984; Soenov and Ebel 1998). However, to crossdate tree rings from a large territory, a regional and highly replicated tree-ring record is needed. A regional tree-ring record should ideally yield common features in its variability

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over long time periods and among different locations and elevations in a mountain region. The regional environmental signal in larch tree-ring variability from cold environments in Altai comes from the limiting impact of summer temperatures on radial larch growth. A strong relationship between summer temperature and larch tree-ring width variability has been demonstrated through the vast territory of the Altai Mountains at elevations from 2400 to 1400 m asl (Panyushkina and Ovtchinnikov 1999).

We studied tree rings of larch in the southeastern part of the Russian Altai to develop a 3000-yr tree-ring record that captures regional-scale tree-ring width variability. The main goal is to bridge a gap between tree rings of the Pazyryk culture and modern larch from summer temperature-controlled environments (upper tree-lines). Our objectives are 1) to develop well-replicated tree-ring chronologies from the archaeological timbers and 2) to determine calendar ages of the floating chronologies through ^{14}C dating and crossdating of the tree rings. In this study, we report ^{14}C dating of floating tree-ring chronologies from numerous archaeological sites of different archaeological times, and the progress on merging them with an absolute calendar tree-ring chronology from living trees. We focus our result discussion on ages of floating tree-ring chronologies and the gaps between them.

MATERIALS

Archaeological timbers were obtained through re-excavation of previously studied sites with reburied timbers and through collaboration with Siberian archaeologists and museums. Table 1 shows the geographic distribution and size of tree-ring sample collections for each studied archaeological site. Our tree-ring data sets include tree-ring width measurements from timbers of the Pazyryk, Hun-Sarmatian (AD 300–500), and Turk periods (AD 500–900) in the Russian Altai. The Pazyryk timbers were collected from 3 locations in the southeastern Altai Mountains: the Ulagan River Valley (the Pazyryk tombs), the Chuya River Valley, and the Ukok Plateau (Figure 1). The Pazyryk tombs are situated at elevations between 1400 and 2345 m asl. The tree-ring data set includes larch timbers from small tombs of ordinary people and elite tombs of the nobility. In the Chuya region, 98 tree-ring cross-sections were recovered through re-excavations of 13 small tombs at the Ulandryk-1 burial field, previously studied by Kubarev (1987). Twenty-seven specimens from 12 small tombs were obtained by Kubarev from several burial fields along the Barburgazi and Yustid rivers (Chuya Valley). Thirty-eight cross-sections from elite tombs from the Ulagan and Ukok locations were subsampled from archives of the State Hermitage Museum and Institute of Archaeology and Ethnography, Siberian Branch of the Russian Academy of Sciences (Rudenko 1970; Molodin 1995; Polosmak 2001). Another 21 tree-ring series from 5 small tombs in the Ukok region were also studied (Sljusarenko 2000). A further series of tree rings comes from the Kurayka graveyard (Kok-Pash culture of Hun-Sarmatian period) at an elevation of 1627 m asl. The Kurayka site includes more than 120 graves situated along a high terrace of the Eponymous River, studied by Soenov and Ebel (1998). Eleven tree-ring specimens of larch were sampled from 4 graves. Finally, 9 poles from 3 stone enclosures at the Tergun, Kizil-Shin, and Chagan-Uzun sites (Turk) were obtained. The Turk sites are located in close proximity of each other at an elevation 1764 m asl. Both sites from the Turk and Hun-Sarmatian periods are situated in the Chuya River Valley (Figure 1), which is the middle and most replicated cluster of the Pazyryk tombs.

Table 1 Geography and number of tree-ring specimens from the studied archaeological sites (* marks elite tombs of the Pazyryk culture).

Region/site	Archaeological culture	Latitude (N), Longitude (E)	Altitude (m asl)	Tombs or graves ID number	No. of tree-ring width series
Bishkaus					
Pazyryk*	Pazyryk	50°59′, 87°51′	1400	1, 2, 3, 4, 5	22
Chuya					
Ulandryk-1	Pazyryk	49°40′, 89°06′	2150	1, 2, 3, 4, 5, 6, 7, 9, 11, 12, 13, 14, 15	98
Ulandryk-4	Pazyryk	49°38′, 89°04′	2150	1	1
Yustid-12	Pazyryk	49°54′, 90°02′	2150	21, 22, 27, no #	10
Barbugazi-1	Pazyryk	49°49′, 89°10′	2060	14, 17, 18, 21, 25	13
Tashanta-1	Pazyryk	49°48′, 89°16′	1990	1, 2	3
Kurayka	Hun-Sarmatian	50°14′, 87°57′	1627	5, 8, 49, 101	11
Tergun	Turk	50°01′, 88°29′	1764	1 stone enclosure	7
Kizil-Shin	Turk	50°01′, 88°29′	1764	1 stone enclosure	1
Chagan-Uzun	Turk	50°01′, 88°29′	1764	1 stone enclosure	1
Ukok					
Ak-Alakha-1	Pazyryk	49°18′, 87°33′	2200	1	2
Ak-Alakha-3*	Pazyryk	49°18′, 87°33′	2200	1	9
Kuturguntas-1	Pazyryk	49°26′, 87°35′	2105	1	5
V.-Kaljin-1	Pazyryk	49°23′, 87°34′	2345	1	5
V.-Kaljin-2*	Pazyryk	49°23′, 87°34′	2345	1, 2, 3	14

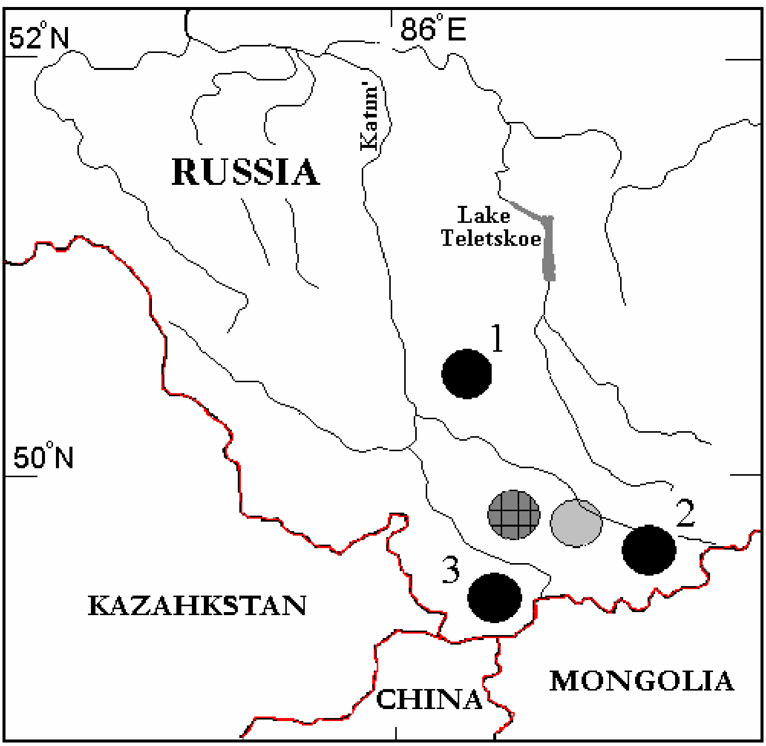

Figure 1 Location of studied archaeological sites in the Altai Mountains. Black dots are clusters of Pazyryk culture sites: 1 - Bishkaus River Valley (the Pazyryk tombs); 2 - Chuya River Valley and Ulandryk-1 burial field; 3 - Ukok Plateau (see Table 1 for details). The gray dot represents Turk culture sites and the hatched gray dot is the Hun-Sarmatian site. Ten upper tree-line sites of living and remnant larch located between tomb clusters at the Chuya River Valley and Hun-Sarmatian site are not shown.

METHODS

The tree-ring widths were measured on a Henson measurement system (with 0.01-mm accuracy) at the Laboratory of Tree-Ring Research, University of Arizona. Tree-ring width series were crossdated within a tomb or a grave using TSAP® software (RINNTECH, www.rinntech.com). Tomb/grave tree-ring width chronologies were overlapped within a site, or between sites, where possible. Quality control of crossdating was checked through Pearson correlation coefficients and *t* values calculated in the TSAP and COFECHA programs (Holmes 1983). Floating tree-ring width chronologies were developed by averaging crossdated tree-ring series without detrending tree age. ^{14}C dates were determined at the University of Arizona NSF-AMS facility. We used subsamples of 10-yr or 5-yr tree-ring sequences separated from crossdated specimens for accelerator mass spectrometry (AMS) dating. The α-cellulose fraction of the wood was first separated, then combusted to CO_2 and converted to graphite via reduction with iron. The graphite was used in the targets for AMS analysis. ^{14}C dates were calibrated against the Northern Hemisphere terrestrial curve with CALIB v 5.0.2 (Stuiver and Reimer 1993). Wiggle-matching techniques based on Monte Carlo modeling were applied to derive precise calendar ages of ^{14}C dates from Kurayka tree rings of the Hun-Sarmatian period. Several ^{14}C dates were developed to control overlaps between tree-ring width chronologies of tombs and sites. A 1586-yr tree-ring width chronology of larch (AD 420–2005) from 10 upper tree-line sites of southeastern Altai was used as a reference curve for tree-ring crossdating where possible (extended tree-ring chronology from Panyushkina et al. [2005]).

RESULTS AND DISCUSSION

Composite Tree-Ring Chronology of the Pazyryk Culture

Timbers from Pazyryk culture tombs were scattered through 1000 m of elevation and an area of about 3600 km^2 (Figure 1). To develop a regional tree-ring record, we cautiously established tree-ring dates in 3 geographical clusters of tombs and then overlapped them in a composite tree-ring chronology. The core of the composite chronology is the Ulandryk-1 master curve from the Chuya Valley cluster. Ulandryk-1 timbers came from 13 small Pazyryk tombs spread within a few meters of each other at the elevation of modern upper tree-lines. The master chronology is 421-yr long and averages 98 tree-ring series in total (Figure 2A). The time span of tomb tree-ring chronologies varies from 133 to 396 yr and depends on the type of burial timbers. For example, chamber beams from a group burial contain the maximum number of tree rings and a wooden coffin from a child burial has the minimum ring count. The mean sensitivity of the tree-ring chronology is 0.28, and the mean correlation coefficient between tree-ring series in the chronology is 0.41 and significant. Correlation coefficients between tree-ring width series within a tomb are even higher and range between 0.6 and 0.7. This suggests a single timber source used for tomb construction. The Ulandryk-1 master chronology has a large sample size and sample depth through almost the entire length of the chronology (Figure 2A), which produces the well-replicated and reliable tree-ring record.

We attempted to establish the absolute age of the Ulandryk-1 floating tree-ring width chronology. To date its oldest end and verify overlaps of tree-ring series, we obtained 3 ^{14}C dates for tombs #14, #13, and #15 from pith inner rings positioned with crossdating (Table 2). Calibrated ages for the pith rings were 810, 800, and 790 BC, respectively, which seems to match well with the relative position of these 3 specimens in the master chronology. This dates the oldest end of the Ulandryk-1 chronology to ~810 BC. To determine the absolute age of the youngest end of the floating chronology, we compared the master chronology with a tree-ring series from the Ulandryk-4 burial field, where tomb #1 is located just a few hundred meters away from the Ulandryk-1 cemetery. The Ulandryk-4 (k.1) tree-ring series had been used to develop a ^{14}C wiggle-match for a small tomb by Sljusarenko et al. (2004). The outermost rings of the Ulandryk-4 (k.1) series dated to ~310 BC. The Ulandryk-1 master tree-ring chronology was successfully crossdated with tree-ring width series from Ulandryk-4 (k.1). The tree-ring overlap places the youngest end of the Ulandryk-1 master chronology at ~300 BC. However, using this end date with the 421-yr length of the tree-ring chronology, the oldest end of the Ulandryk-1 chronology would give a date of ~720 BC, which is about 100 yr younger than shown by the 3 ^{14}C dates from the oldest end of the master chronology. A 720 BC date may be more accurate than a 810 BC date because of the influence of the so-called Hallstatt plateau on the ^{14}C calibration curve in this time period.

Table 2 ^{14}C dates of archaeological timbers used to control of tree-ring overlaps (note: the Kurayka ^{14}C wiggle data are not included).

Site and lab ID	^{14}C age (BP)	Calibrated yr (1 σ)	No. of rings / their crossdated position in tree-ring chronology
Ulandryk-1			
Tomb 13: AA55397	2616 ± 37	810–780 BC	10/261–270
Tomb 14: AA55393	2656 ± 37	840–800 BC	10/132–141
Tomb 15: AA55395	2563 ± 42	800–750 BC	10/166–175
Kurayka			
Grave 49: AA55394	2088 ± 36	150–50 BC	10/19–28
Grave 101: AA69233	1893 ± 32	AD 60–130	10/52–63
Tergun			
Pole 8: AA55396	1747 ± 36	AD 240–340	10/46–55
Pole 3: AA69265	1474 ± 40	AD 560–630	10/339–348
Pole 7: AA69264	1425 ± 40	AD 600–650	5/380–385
Pole 1: AA69266	1347 ± 40	AD 650–690	3/23–25 series
Kizil-Shin		AD 750–760	
Pole 1: AA69255	1843 ± 41	AD 130–230	10/362–371
Pole 1: AA69267	1610 ± 10	AD 415–430	10/402–411
		AD 500–510	
		AD 520–530	

The next element of the composite chronology was developed from 5 overlapping tomb chronologies for the Pazyryk site (Bishkaus Valley cluster). All cross-sections came from chamber beams. The Pazyryk tomb chronologies have only 3 tree-ring cross-sections per tomb with the exception of tomb #5. The Pazyryk tomb #5 chronology averages 10 cross-sections, 6 of which were subsampled from the Pazyryk timber collection of the State Hermitage Museum (St. Petersburg), and the remaining cross-sections were cut off from logs found at the bottom of the crater left after the tomb excavation by Rudenko (1970). The span of tomb tree-ring chronologies varies from 163 to 242 yr. We observed that the tree-ring widths are wider, indicating a local source of harvested timbers from an elevation of 1400 m asl. Despite that fact, the mean tree-ring sensitivity of the tree rings is high (about 0.31). Five tree-ring chronologies from the Pazyryk site overlapped in a 295-yr site chronology. The mean correlation coefficient of the site chronology is about 0.7. Only the tree-ring chronology of Pazyryk tomb #1 showed lower correlation within the overlap (0.47), which is still significant. We did not develop any ^{14}C dates for the floating Pazyryk tree-ring chronology because the timbers were already intensively studied with ^{14}C (Zaitseva et al. 2005). Comparison of ^{14}C wiggles from the Ulandryk-4 (tomb #1) incorporated in the master Ulandryk-1 chronology and Pazyryk-2 tree-ring series shows they are coherent with each other (Hajdas et al. 2004). This suggests that the most likely match for the Pazyryk tree-ring chronology is at the youngest end of the Ulandryk-1 master tree-ring chronology. Statistically, we found that the best match of the Pazyryk chronology is in the period of years 191–421 of the Ulandryk-1 master chronology. The overlap length is 231 yr; this overlap extends the length of the composite tree-ring chronology to year 486. The main cross-dating statistics of the overlap are significant at the 99% confidence level. The standard *t* value is 5.7, the cross-correlation coefficient is 35%, and the Gleichlaeufigkeit coefficient (sum of the equal slopes interval) is 59%. Visual examination of the plotted Pazyryk tree-ring width series within the overlap is consistent with the statistically selected match of the Pazyryk tree-ring chronology. The overlap of the developed tree-ring chronologies suggests the age of Pazyryk tomb #5 is ~240 BC.

The last component of the composite tree-ring chronology of the Pazyryk culture was developed through merging tree-ring series from 17 tombs of the Ukok Plateau and Chuya Valley. Those tombs have a limited number of specimens per tomb, in some cases only 1 or 2 tree-ring series. Because our main focus is to extend the floating chronologies, we matched every single tree-ring series available. Nevertheless, the crossdated tree-ring series did not extend the composite tree-ring chronology. The dates of the Chuya and Ukok tombs tend to overlap towards to the youngest end of the chronology. Figure 2A shows total tree-ring sample numbers for each studied region merged into the composite chronology of Pazyryk culture. The composite chronology shows an 85-yr period of tomb development. The tree-ring data indicates that the small tombs were established first and the elite tombs appeared later. The 2 most well-studied elite tombs of the Pazyryk culture—the Ak-Alakha-3 tomb #1 (tomb of the Siberian Ice Maiden) and the Pazyryk tomb #5—were constructed 43 yr apart according to the composite tree-ring chronology.

Dates for Graves from the Hun-Sarmatian Period

We unearthed timbers from 4 graves at the Kurayka site associated with the Kok-Pash culture. Graves #5 and #8 were re-excavated and graves #49 and #101 located next to each other were excavated. The graves were typologically dated between about AD 300 and 500 based on burial features and the chronology of arrowheads derived from previous studies (Soenov and Ebel 1998). Each grave had a wooden coffin carved out of a larch trunk. Multiple tree-ring samples were taken from each coffin to recover the maximum ring count (Table 1). None of tree-ring specimens had a cutting date because of outer woodworking. Tree-ring width series from 1 grave were crossdated with each other and averaged into a grave tree-ring chronology. The length of grave chronologies varies from 81 to 130 yr. These grave tree-ring chronologies were overlapped into a 144-yr site tree-ring chronology that actually averaged only 4 trees. Grave tree-ring chronologies correlate well with each other (mean correlation 0.44). Two ^{14}C determinations on samples from timbers in graves #49 and #101 were obtained to verify the overlaps. These appeared to be out of order. The two 10-ring subsamples are 34 rings apart according to crossdating and 185 ^{14}C yr apart according to the ^{14}C measurements (Table 2). To examine this further, we obtained 11 ^{14}C dates from a 110-yr tree-ring chronology in grave #49 to position the Kurayka floating chronology in calendar time. The ^{14}C wiggle dates the tree-ring chronology of grave #49 to between about AD 75 and 195 (Figure 3). It places the floating tree-ring chronology of the Kurayka site between about AD 70 and 240. Consequently, the ^{14}C date of grave #101 enabled us to confirm the suggested tree-ring overlaps. The tree-ring chronology evidence suggests that this represents the early part of the Hun-Sarmatian period in the Altai area, previously based on typological dating.

Dates for Turk Stone Enclosures

We excavated larch poles from stone enclosures in Turk ritual complexes at the Tergun, Kizil-Shin, and Chagan-Uzun sites (Figure 1, Table 1). The poles (1.2 m long, ~0.3 m diameter) were exposed only a few cm above the ground. The number of buried poles per site varied from 1 to 8; however,

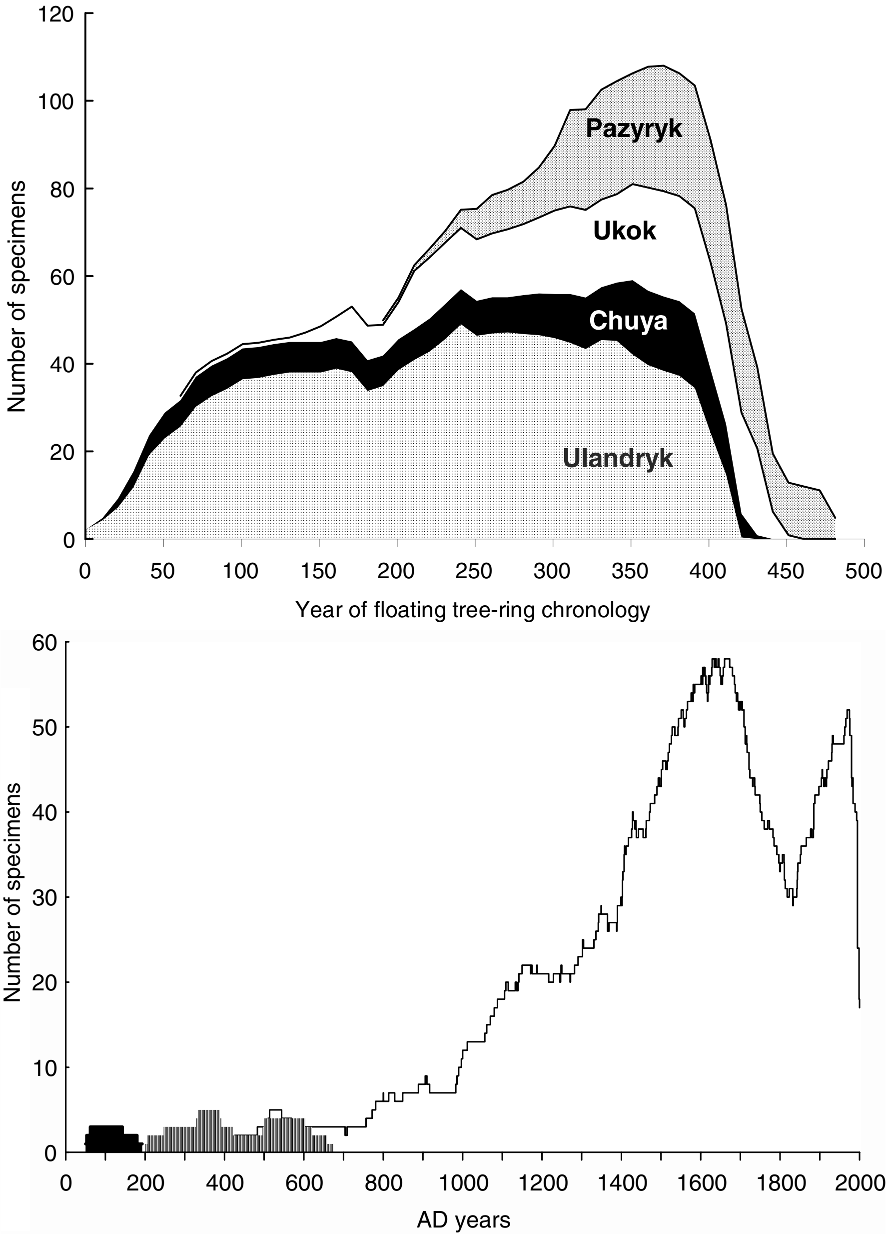

Figure 2 A) Stacked plot of the total number of crosdated tree-ring width series showing regional distribution of tree-ring specimens from the Pazyryk culture tombs. Pazyryk and Ukok tomb groups include elite tombs of Pazyryk nobility. Timbers of the Ulandryk group form the core of the composite floating tree-ring chronology of Pazyryk culture in the Altai Mountains. B) Sample depth of the Hun-Sarmatian (black area) and Turk (gray area) floating tree-ring chronologies and the upper tree-line chronology (black line) from the Russian Altai.

not all poles were suitable for tree-ring measurements due to wood decay. Seven tree-ring series from the 3 sites overlapped in a 475-yr floating chronology. The length of the tree-ring series ranges from 141 to 347 yr. The overlap length for most tree-ring series was equal to the total length of the

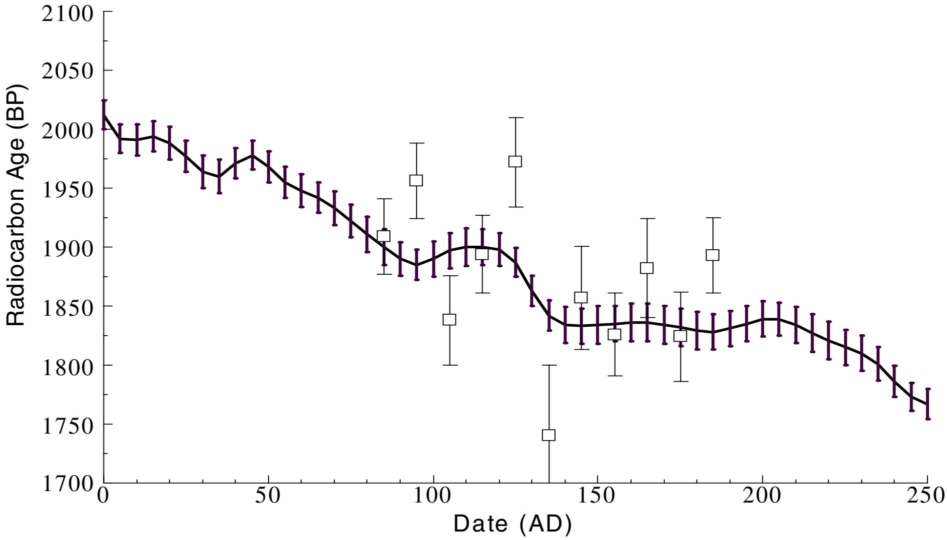

Figure 3 A 110-yr ^{14}C wiggle for tree rings of the Hun-Sarmatian culture plotted against the IntCal04 ^{14}C calibration curve (Reimer et al. 2004). Each square represents the ^{14}C date of a 10-tree-ring subsample from crossdated tree-ring series of grave #49, Kurayka site. Error bars are 1 σ.

tree-ring series. The mean correlation coefficient between tree-ring series is 0.48. Three ^{14}C dates from the overlapped tree-ring series are consistent with crossdated positions of the tree rings (Table 2). Only 1 ^{14}C date (AA69255) from the Kizil-Shin site misrepresents the age of the wood. Two ^{14}C dates from the same specimens developed from 10-yr ring subsamples were 300 yr apart; however, crossdating shows only 31 yr (rings) between them. Two other dates (AA69264 and AA69265) from the overlapped tree rings reproduce the ^{14}C measurement error. In this particular case, the tree-ring crossdating exposed the error in the ^{14}C measurement. According to the ^{14}C dates, this floating chronology spans between cal AD 200 and 650. A match for a 107-yr tree-ring width series from the Tergun pole #7 was not found. The end of this series was ^{14}C dated to between cal AD 600 and 650. Although there is no time gap between the Altai upper tree-line tree-ring chronology (AD 420–2005) and the Turk floating chronologies, we failed to establish a statistically robust tree-ring overlap between them. This does not mean that it is impossible. For example, tree-ring width series from the Tergun pole #1 was bridged with the Altai upper tree-line chronology for the period AD 709–829. A ^{14}C date from the pith rings of the specimen corresponds well with the matched position of tree rings, which is AD 750–760 (Table 2). It seems that the low sample depth of the Altai chronology between AD 420 and 760 prevents the overlapping (Figure 2B). Nevertheless, the ^{14}C dates and crossdating indicate that the larch poles were incorporated in the burial enclosures between AD 450 and 840. This means that the pole tree-ring chronology represents almost the whole period of Turk history in the Altai (Gorbunov and Tishkin 2003).

3000-yr Tree-Ring Record in Russian Altai

Tree rings from archaeological timbers dating to the 1st millennium BC and the 1st millennium AD show good potential for eventual overlap with a modern larch chronology, to produce a 3000-yr record for archaeological dating purposes. Our study demonstrated some very successful results, and other less successful results, on merging floating tree-ring chronologies from the vast mountain area. Current progress on the 3000-yr record of larch tree rings indicates 2 major problems. First, there is a ~300-yr gap between the Pazyryk culture composite chronology and the next floating segment of the larch record from the Hun-Sarmatian period. The gap is dated between cal 240 BC and cal AD 70. An absence of timbers in that period might be related to cultural changes and migrations in the Eurasian steppe. Obviously, more excavations and field studies at Siberian Scythian sites are needed. Second, 2 other floating chronologies from the Hun-Sarmatian and Turk periods do not have statistically significant overlaps (Figure 2B). This might be improved by increasing sample depth for both the upper tree-line tree-ring chronology and the archaeological tree-ring chronologies. It is important to recognize that not every piece of larch wood might be crossdated with the regional tree-ring chronology. Only tree rings that are sensitive to summer temperature have a chance to be incorporated into the chronology. Timbers recovered from high elevation would have a greater chance than timbers from low elevation. Because the environmental location of archaeological timbers is unknown, low-elevation sites might have precipitation-sensitive as well as summer temperature-sensitive rings.

CONCLUSIONS

The effort to develop a 3000-yr tree-ring record of larch in the Russian Altai by merging archaeological and upper tree-line tree rings has been significantly advanced. ^{14}C dating of tree rings, along with tree-ring crossdating, has succeeded in improving the precision and reliability of dates for the floating tree-ring chronologies, and verified tree-ring overlaps. The record includes the following segments: a 486-yr composite tree-ring chronology for the Pazyryk culture (about 720–240 BC), a 144-yr tree-ring chronology for the Hun-Sarmatian period (about AD 70–240), a 475-yr tree-ring chronology of Turk sites (AD 450–840), and an upper tree-line tree-ring chronology (AD 420–2005). A major 300-yr gap occurs between about 240 BC and AD 70. The composite chronology dates the earliest construction of the Pazyryk culture tombs at ~320 BC (ordinary tombs) and the latest at ~240 BC (Pazyryk noble tomb #5). It confirms previous observations that the tombs are about 200 yr younger than the typological chronology would suggest. We suggest applying the composite tree-ring chronology to dating tree-ring specimens from Scythian tombs of 500–600 BC in the region. This will help to confirm the precision of ^{14}C dating for the Scythian tombs around the Hallstatt plateau of the ^{14}C calibration curve. Dates derived from tree rings of Hun-Sarmatian and Turk sites present the first absolute dating of these periods in the Altai and contribute to the development of an independent chronology to precisely date typological chronologies currently used. Overall, we strongly recommend using crossdated sequences of tree rings for ^{14}C dating rather than randomly taken tree-ring subsamples. In this study, 2 out of 22 ^{14}C dates appeared to have errors. This was successfully identified through tree-ring crossdating.

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