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Y.N. Garkusha
Institute of Archaeology and Ethnography,
Siberian Branch, Russian Academy of Sciences,
Pr. Akademika Lavrentieva 17, Novosibirsk, 630090, Russia
E-mail: yunga1971@ngs.ru

Log Cabins of Ust-Voikary, a Fortified Settlement in Northwestern Siberia: Dendrochronological Analysis

Ust-Voikary is a stratified settlement complex associated with the indigenous population of Northwestern Siberia and spanning the period from the Middle Ages to the recent centuries. It is one of the few sites in the region with the habitation layer preserved in the permafrost. Architecturally, it is marked by the prolonged coexistence of two types of wooden buildings—frame-and-post constructions and log cabins. Wood from nine log cabins excavated in 2012–2016 was subjected to dendrochronological analysis. The findings suggest that the earliest structures of that type date to the late 1400s. The proportion of types and the chronology of structures suggest that log cabins predominated by the mid 18th century. In the late 18th century construction activity at the site ceased. Later stages in the history of Ust-Voikary largely correlate with those of other indigenous stratified sites such as the Nadym and Polui promontory forts. However, at the latter sites, archaic frame-and-post buildings predominate.

Keywords: *Northwestern Siberia, Ust-Voikary, log cabins, dendrochronology.*

Introduction

The Ust-Voikary fortified settlement is located in the Shuryshkarsky District of the Yamal-Nenets Autonomous Okrug, about 130 km southwest of the city of Salekhard, on the left bank of the Gornaya Ob Channel, which is one of the branches of the Malaya Ob River. Since 2003, the site has been studied by the team from the Institute of Archaeology and Ethnography of the Ural Branch of the Russian Academy of Sciences and the Shemanovsky Yamal-Nenets District Museum and Exhibition Complex (supervised by A.G. Brusnitsyna and N.V. Fedorova) (Brusnitsyna, 2005; Fedorova, 2006). At the last stage (2012–2016), the archaeological works of the team from the Institute of Archaeology and Ethnography SB RAS were led by A.V. Novikov (Novikov, Garkusha, 2017).

Archaeological study of the site has revealed that it was a stratified settlement complex inhabited by the indigenous dwellers of northwestern Siberia. The excavations focused on its visually distinctive part—a hill formed by accumulated woodworking waste. Thus, the conclusions about various aspects of the settlement's history from the literature should be correlated with this particular part of the site (Garkusha, 2020).

The dendrochronological study that was initiated by M.A. Gurskaya from the Institute of Plant and Animal Ecology of the Ural Branch of the Russian Academy of Sciences was carried out simultaneously with archaeological works. Most of the wood was obtained from the objects located on the top of the hill; another part was sampled from those at its foot. The fact that the material evidence belonged to extreme (in terms of stratigraphy) cultural layers has made it possible to

Data on log cabins investigated in 2012–2016

No. of building*	Number of samples	Number of undated samples, %	Length of TRC, years	Chronological interval	Glk, %	TBP	CDI	r
1	48	16	336	1354–1689	68	13.1	92	0.57
2	19	10	149	1431–1579	63	6.4	45	0.44
3	20	30	53	1461–1513	72	3.3	29	0.57
3A	12	16	132	1335–1466	77	11.0	87	0.80
5	2	–	194	1274–1467	70	8.8	57	0.67
7	52	13	185	1561–1745	68	10.4	73	0.70
9	12	–	210	1539–1748	62	4.8	34	0.43
9A	14	14	299	1443–1741	65	7.9	51	0.50
10	12	16	176	1567–1742	69	10.3	74	0.69

*The alphanumeric designation of buildings was used during field works in the cases when it was difficult to separate them into tiers. Such designation continues to be used in further work with the evidence from the site, in order to avoid confusion with information already given in publications and reports.

establish the overall period of economic activities in this part of the settlement, which lasted from the late 13th to 19th century (Gurskaya, 2008).

This article presents the results of dendrochronological dating of log structures investigated in 2012–2016*. Over the entire period of excavations, seventeen such structures were discovered at the site. Eight of them were identified in 2012–2016; in the same period, the study of another building, which was partially excavated and conserved during the first stage of research, was completed. Typical single-chamber log cabins were made of logs (unless otherwise specified) with overlapping corners.

From 2 to 52 wood specimens were sampled from each structure, depending on their space, degree of destruction, and preservation of the wood (see *Table*). The wood was represented by coniferous species, including 63 % Siberian spruce (*Picea obovata* Ledeb.), 30 % Siberian larch (*Larix sibirica* Ledeb.), and 7 % Siberian pine (*Pinus sibirica* Du Tour). Wood species were established using specific identifying features (Benkova, Schweingruber, 2004). In terms of age composition, the specimens were divided into six groups: I – up to 50 years of age, II – 51–100, III – 101–150, IV – 151–200, V – 201–250, and VI – over 250 years of age (Chernykh, 1996: 36).

Methods

A LINTAB-6 semi-automatic unit (with accuracy of 0.01 mm) was used for measuring the growth ring width. The obtained growth series were compared using the cross-dating method with the specialized program TSAP-Win Professional (Rinn, 2013), which ensures parallel visual control of comparison between growth graphs* and the calculation of statistical parameters for each variant of their combination.

The cross-dating quality was established by means of standard statistical indicators used in the TSAP program:

– TBP coefficient—t-statistics adapted according to the algorithm of M. Bailey and J. Pilcher, aimed at reducing the low-frequency trend in the initial data (Baillie, Pilcher, 1973);

– Glk coefficient (Schweingruber, 1988: 83), indicating the degree of similarity between two chronologies, which is established from the percentage of coinciding increases and decreases in growth;

– Cross-Dating Index (CDI)—an integral indicator calculated using a set of parameters.

The studies by Gurskaya have shown that the larch tree-ring chronology (TRC) developed using evidence from the southern part of the Yamal Peninsula can be used for dating archaeological coniferous wood from the Voikary settlement and for comparing with the growth series obtained from "local" coniferous wood of various species (2006b). This has made it possible to use the local VKL larch chronology, which we designed using the specimens of archaeological wood, as the main tool for absolute dating of growth series, and to form a generalized TRC for each building by coniferous wood**.

*They had their own numbering. For avoiding confusion, the previously identified objects are marked with an asterisk (*).

*Growth graphs of individual series in this work are presented as semi-logarithmic curves. This format is used to minimize the age trend and facilitate visual comparison of the curves (Kolchin, Chernykh, 1977: 20).

**Statistical characteristics of generalized series for each building are presented in the Table.

The VKL chronology was developed primarily using growth series that were visually and statistically consistent with the Yamal larch master-chronology (Briffa et al., 2013). The series that were in good agreement with the created chronology were added to the generalized scale formed on their basis. The COFECHA program was used for controlling the quality of absolute dating; the quality was based on the values of the correlation coefficient *r* (Holmes, 1983; Grissino-Mayer, 2001).

The length of the VKL tree-ring chronology was 446 years; the chronological interval was 1302–1747. The quality of cross-dating of the VKL chronology with the Yamal tree-ring chronology was confirmed by high values of statistical indicators: Glk was 70 %; TBP was 15.5; CDI was 108, and *r* was 0.59.

Before using the chronology for dating, it is recommended to carry out a standardization procedure that minimizes the impact of non-climatic factors. This procedure was performed using the ARSTAN program (Cook, Krusic, 2005). The smoothing spline method was chosen for standardization (Cook, 1985: 76–87). This method is distinguished by flexibility as compared to other standardization methods, and is used quite widely despite the fact that it has some disadvantages (Klesse, 2021).

While working with historic wood, any element that can be dated is a local source of information on construction activities (see, e.g., (Jansma, Haneca, Kosian, 2014; Haneca, Debonne, Hoffsummer, 2020)). In this regard, the dating procedure included some specimens that have been usually excluded from studies aimed at constructing various kinds of generalized chronologies. These traditionally include specimens with less than 50–60 rings, as well as those containing abnormal eccentric growth layers (compression wood). The validity of such an approach (provided that a number of conditions are followed) is confirmed by successful examples of dating the evidence from the sites along the northern boundary of the forest zone (see, e.g., (Shiyatov, Hantemirov, 2000; Omurova et al., 2013: 191)).

For analyzing the data, the individual growth series were combined into groups according to the position of specimens in certain structural elements of the buildings. In this context, the additional information obtained from undated specimens (species and age of wood, type of building material, etc.) was also taken into account. This approach fosters a more complete reconstruction of building activities.

Results

Building 1. Groups of specimens representing the main structural elements of the building: "log layers", "facing", and "stacking"*. The rest of the specimens are associated with various filling areas. Most of the specimens were spruce; only 6 % (mainly from the "facing" group) belonged to larch. Wood over 100 years old made up 35 % of the entire sample. Trees of age groups III and IV served as material for the log layers and "facing". Most of the specimens were taken from logs and partly from poles (various fasteners, posts, and floor beams). Planks were found exclusively among the elements of "facing".

Comparison of growth series within the groups demonstrates generally high values of statistical indicators. For instance, the following values were obtained (the overlapping area between growth series was 53–181 years) for the group of "log layers": Glk – 69–74 %; TBP – 4.6–7.2, and CDI – 32–86. Unambiguous results of relative dating are demonstrated, for example, by larch specimens from the "facing" elements (overlapping area 61–183 years): Glk – 67–84 %; TBP – 5.2–13.1, and CDI – 31–103 (Fig. 1). Values close to the maximum suggest that some elements could have been made from a single tree trunk.

The quality of dating according to the VKL chronology was manifested by acceptable values. The main range of change in the *r* coefficient was 0.41–0.66; in isolated cases, it was 0.38–0.40.

The sample contained 18 % of specimens with 50 rings or less; 18 % of them could not be dated. Absolute dating, with a few exceptions, showed statistical significance acceptable for this category of series: Glk – 65–71 %; TBP – 4.1–6.8; CDI – 30–45, and *r* – 0.48–0.66.

Timber for the log layers was mainly harvested in the autumn–winter of 1689/90. Dates of peripheral rings** in a part of the specimens from this group slightly lag behind that period. Thus, we can assume the simultaneous procurement of building material for the log layers. A case of reused wood was established: the tree had been cut down 22 years earlier.

The dates of the specimens with subcrustal rings are generally in the range of 1501–1689, which looks extraordinary for a building of about 7 m^2. The distribution of dates of the elements, in terms of their functional purpose, suggests that some of them could have belonged to previous structures, whose remains were used to build the log cabin. The construction practice when individual structural elements of a previous building were reused in a new building was repeatedly observed during the excavations. This was facilitated by their layered location

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*The "facing" consists of fragments of vertically set planks located under the lower log layer. The "stacking" is made up of five threshold logs stacked on top of each other under the front wall of the log cabin.

**A peripheral ring is the last measured ring, which may not coincide with the subcrustal ring.

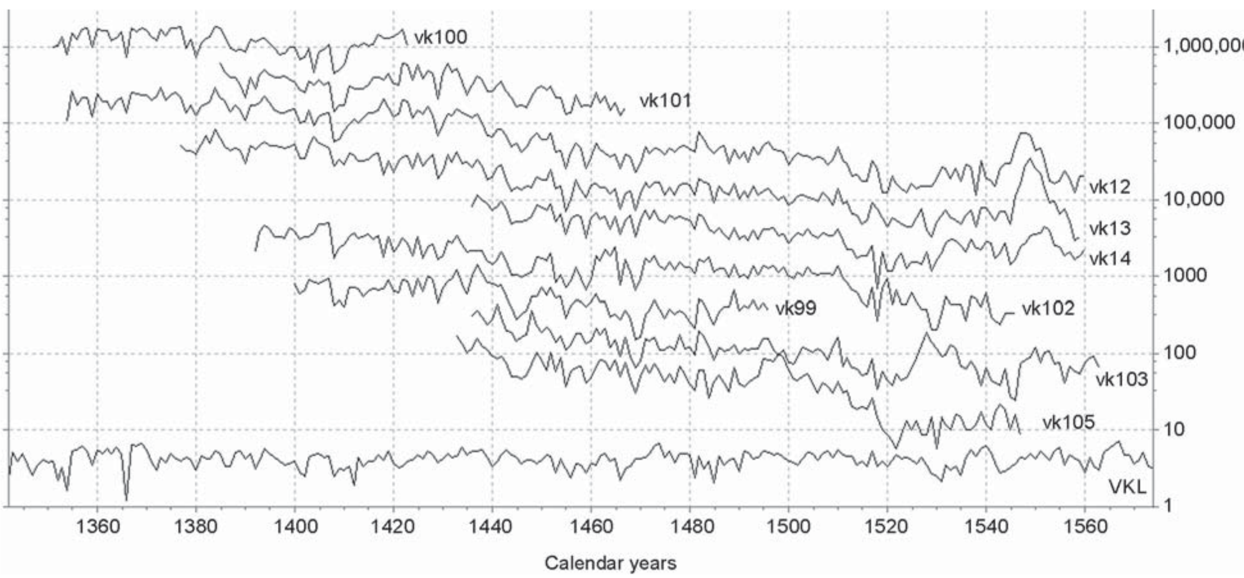

Fig. 1. Cross-dating of individual series based on specimens from the "facing" group of building 1.

directly on the ruins of past structures. Hence, it was difficult to establish clear stratigraphic markers between adjacent structures. Some elements of an earlier structure, while maintaining relative architectural integrity, often acquired a new purpose. For example, based upon analogy with other similar contexts, the "facing" consisted of the remains of vertically-set outer walls belonging to the previous frame-and-post dwelling. In their new capacity, they served to strengthen the walls of the recess along the perimeter of which the log cabin was set (Fig. 2). This assumption is also supported by the fact that the dates of the elements in each group constituted chronologically similar sets. Therefore, the difference in dates did not only result from arbitrary reuse of timber. For example, the dated elements of the "stacking" were from 1627–1650, which corresponds to their stratigraphic position; a relatively large part of the dates of the specimens in the "facing" group gravitated towards the 1560s, etc. According to the totality of data, fewer elements actually belonged to building 1, erected at the end of the 1680s–beginning of the 1690s, than were attributed to it at the stage of field research.

Building 2. The specimens were divided into groups of "log layers", "platform" (a row of short logs located under one of the walls), and also according to various areas of the filling. About 60 % of the specimens belonged to spruce; the rest belonged to larch. In the sample, 42 % of the wood was over 100 years of age. Wood belonging to age group II made up 42 %, whereas that of group I was 16 %. Timber of both species of about 120 years of age was used for the log layers. Trees of groups I–III were used for making the elements of the "platform". The vast majority of building material was logs; half-logs were sporadic.

After comparing the growth series, the best values of statistical indicators were: Glk – 62–77 %; TBP – 4.0–6.8, and CDI – 31–44. Absolute dating showed relatively high values: Glk – 68–72 %; TBP – 5.0–8.2; CDI – 35–60, and *r* – 0.41–0.55. Trees for the log layers were harvested in the autumn–winter of 1553/54. The dates of the elements of the "platform" (1552–1553) are consistent with that period, which makes it possible to reliably associate them with that building. A series of later dates (the 1560s) was obtained from the specimens in the filling.

Building 3. This building was covered by building 2. This building (about 5.5 m^2) contained unusual material for dating (Fig. 3). Almost all the specimens (19 out of 20) were obtained from log layers. Young spruce wood was used for making the log cabin: the trees were no more than 54–55 and mostly 35–42 years of age; the youngest tree was 24 years of age. Only a single specimen (from the filling) had 114 rings. Various elements included a partially square log (a log hewn on two opposite sides) and half-logs.

The specific composition of building materials associated with the same structural element implies a purposeful and simultaneous harvesting of the timber from a limited forest area. In addition, radial growth of trees in a given dendroclimatic region is determined mainly by the impact of a single external factor (summer temperatures) (Shiyatov, Hantemirov, 2000). The combination of these conditions is considered sufficient for dating elements made of young wood.

A generalized growth series with a length of 53 years was constructed using the specimens with a maximum number of rings. The series selected for designing the chronology were synchronized by one year. The statistically best calendar matching corresponds to 1513:

Fig. 2. Mutual position of the lower layer and the elements of "facing" in building 1. *Photo by Y.N. Garkusha*.

Fig. 3. Western wall of the log cabin in building 3. *Photo by A.V. Novikov*.

Glk – 72 %; TBP – 3.3; CDI – 29 (the significance level calculated using the TSAP program was 99.9 %), and *r* – 0.57. This date is consistent with the stratigraphic position of the structure between dated buildings. Statistical evaluation of graphical comparison between other growth series and the chronology obtained from the log layer has shown that the best dating variants fit the same year. The specimen from the tree of the oldest age group could not be dated.

Thus, the time when the trees died was the autumn–winter of 1513/14 (Fig. 4). The specific composition of the material suggests that all the timber for log layers from this sample could have been harvested at that time.

Building 3A. The remains of this building were directly under building 3. All the specimens, with the exception of one (from a post that supported one of the walls), were obtained from log layers. Spruce elements were predominant; the rest of the elements were made of larch. The trees belonged to age groups II and III, most of which were about 100 years of age. The specimen from the post belonged to group I.

The series of specimens with surviving subcrustal rings (which were the majority) were synchronized by one year. The series of specimens whose surface condition hampered the identification of such a ring were synchronized by the same year. This suggests that the death of trees from this sample occurred at the same time. The values of statistical indicators revealing the quality of relative dating of growth series form two sets (the overlapping area was 66–110 years): 1) Glk – 65–74 %; TBP – 4.3–9.5, and CDI – 32–74; 2) Glk – 53–71 %; TBP – 3.9 or less, and CDI ranged from 10 to 29. Nevertheless, absolute dating mainly showed high values: Glk – 65–81 %; TBP – 4.2–9.0; CDI – 35–73, and *r* – 0.44–0.55 (the minimum value was 0.38). Thus, the trees were cut in the autumn–winter of 1466/67 (Fig. 5).

Building 5. This building was not excavated; its outline appeared on a slope outcrop. Two specimens were taken from the top log layer. They belonged to the larch of age group IV.

Comparison between the growth series showed significant values: Glk – 70 %; TBP – 8.2, and CDI – 61. The ends of the series corresponded to the same year. The peripheral rings were defined as subcrustal. The calendar matching gave an unambiguous result: with high probability, the trees were harvested in 1467 (Fig. 5).

Building 7. This was the most spacious structure among the investigated log cabins, with an area of about 49 m^2. The specimens were divided into the following groups: "log layers" (6 spec.), "inner walls" (8 spec.), "deckings" (34 spec.), and "hearth structure" (2 spec.); two specimens were associated with the upper level of the filling. Wood of the oldest age made up 73 % of the sample; trees of age group II accounted for 20 %; the share of trees of group I was 7 %. The log layers were made of larch of groups III–V, most of which belonged to group IV. The inner walls were made of logs laid horizontally

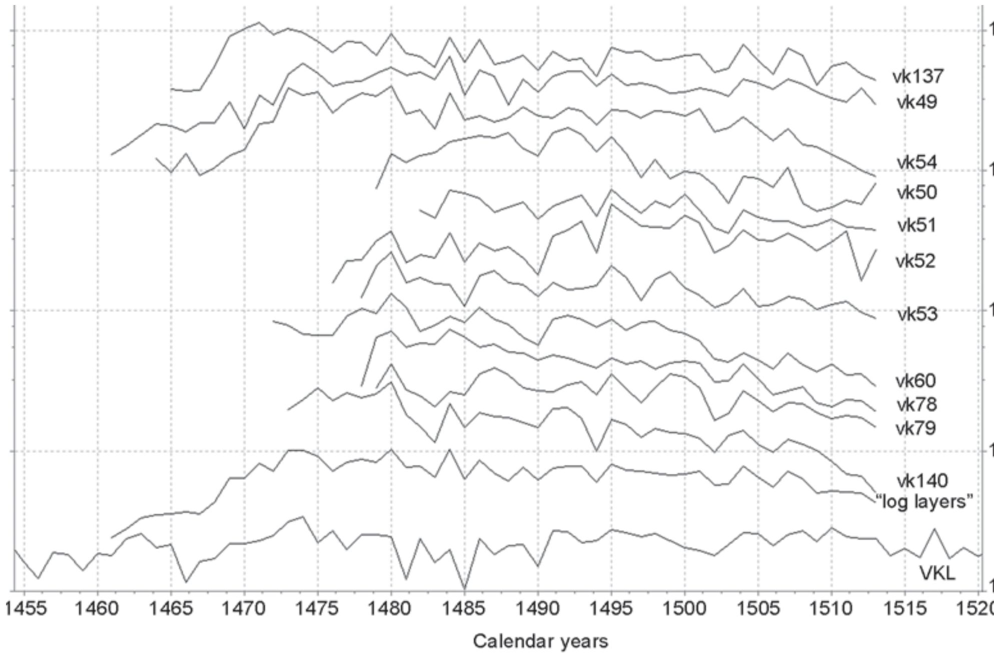

Fig. 4. Cross-dating of individual series based on the specimens from building 3.

Fig. 5. Cross-dating of individual series based on the specimens from buildings 3A (vk171–vk180) and 5 (vk261, vk262).

between posts; they consisted of wood of various types and ages, with the predominant age belonging to group III. The posts were partially square logs made of larch of group III. The wood of the decking was represented by diverse species, ages, and assortment.

Comparison of growth series for the specimens from the log layers has shown two sets determined by the quality of the statistics: 1) Glk – 68–79 %; TBP – 8.4–11.9, and CDI – 32–47 (the overlapping area was 110–186 years); 2) Glk – 65–72 %; TBP – 5.1–7.9, and CDI –

15–28. Nevertheless, the calendar matching was not an issue, since almost all growth series from this group were a part of the VKL chronology. The specimens with subcrustal rings (4 spec.) were synchronized by one year. Their dates corresponded to the autumn–winter of 1738/39. The dates of two specimens with peripheral rings lagged behind by one year and 46 years.

Comparison of growth series based on specimens taken from the elements of the inner walls has mainly shown high values of statistical indicators (the overlapping area was 49–123 years): Glk – 66–82 %; TBP – 4.2–13.5, and CDI – 33–104 (Fig. 6). Synchronization of a pair of growth series based on specimens from the posts (the overlapping area was 122 years) showed maximum values: Glk – 80 %; TBP – 13.5, and CDI – 104. This means that the posts were made from a single tree trunk. Absolute dating was ensured by the presence of most of the growth series from this group in the VKL chronology. For the rest of the series, the results were also unambiguous, with statistical indicators of CDI amounting to 45–64 and *r* in the range of 0.64–0.76. The elements with subcrustal rings revealed a scatter of dates in the range of 1636–1709. The latest date (1747) corresponded to a specimen with a peripheral ring.

In the "decking" group, good indicators of cross-dating were manifested by specimens from the most intensely used central and pre-entrance parts of the room, where the builders chose to use wood of older age: Glk – 63–87 %; TBP – 4.4–14.8, and CDI – 31–130. The growth series formed a chronologically compact group in which, with a few exceptions, the dates of the last rings corresponded to the same year. This suggests a purposeful and simultaneous harvesting of wood. Values close to the maximum (CDI – 88–130) indicate that some parts were made from the same tree trunks. Seven series from this group were included in the VKL chronology. Unequivocal results were also obtained for the rest of the series (CDI – 40–56). Thus, the main array of dates corresponded to the autumn–winter of 1738/39, which is consistent with the results of the dating of the log layers. The extreme dates of some individual specimens corresponded to 1727/28 and 1745/46.

When comparing the series based on the specimens from the elements of decking along the walls, where places for rest were traditionally located, relatively acceptable statistical indicators of synchronization were obtained only for some, because of predominantly young and reused wood in these areas. A limited number of growth series also had calendar matching (*r* – 0.48–0.63). The dates were in the range of 1676–1745; the main array was in the range of 1727–1736.

Comparison of growth series based on the specimens from the hearth structure revealed confident statistical parameters (the overlapping area was 69 years): Glk – 74 %; TBP – 6.1, and CDI – 37. The calendar matching was also beyond any doubts: one growth series was a part of the VKL chronology; for the other series, *r* was 0.74. The date of the only specimen with a subcrustal ring corresponded to the autumn–winter of 1738/39. The dating results for two specimens taken from the elements from the upper part of the filling showed that they occupied chronological positions of not earlier than 1738 and 1745.

Field observations have led us to the conclusion as to the close relationship between the identified structural elements of the building. Thus, the most likely explanation for the scatter in the dates of the elements, as was the

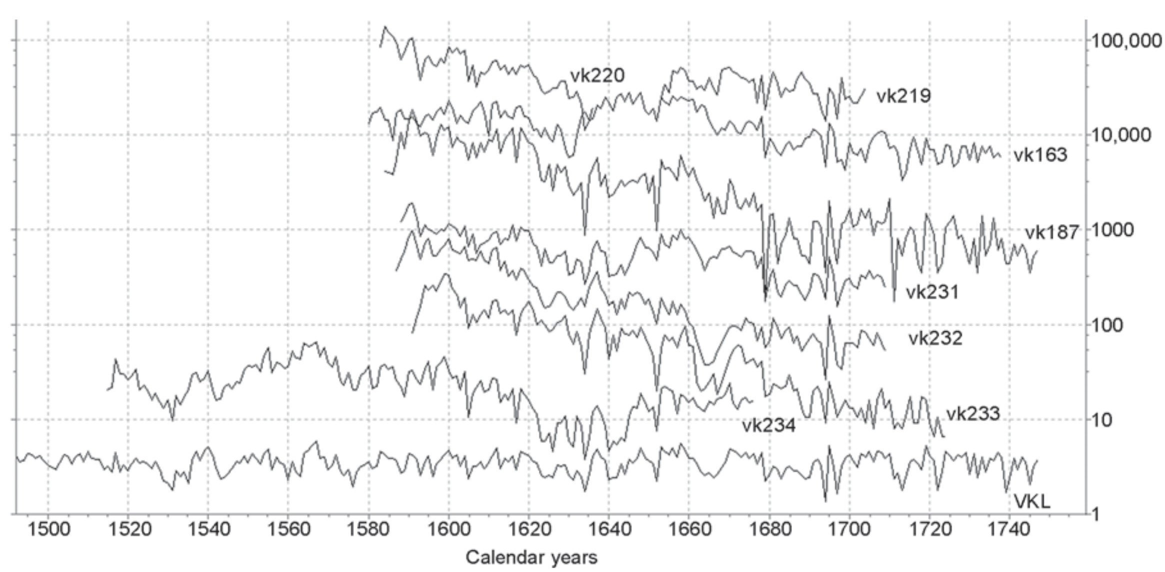

Fig. 6. Cross-dating of individual series based on the specimens from the "inner wall" group in building 7.

case with building 1, is selective inclusion of structural elements of the previous frame-and-post dwelling into the new structure. The remains of the frame of inner walls, as well as individual sections of wooden flooring, which demonstrate the chronological closeness of the elements during the period preceding the construction of the log cabin, can be correlated with the previous structure.

The time of harvesting trees for the log layers corresponds to the autumn–winter of 1738/39. The dates of most of the specimens from the elements of the decking in the central and pre-entrance parts of the room, as well as the hearth structure, were consistent with this period. This means that wood harvested for this purpose was mainly used for constructing the house. The latest dates (1745–1747) were obtained for several details from various elements of the structure, associated with local repair works.

Building 9. This is the conserved building 6*, which was discovered in the first years of studying the site (Fedorova, 2006: 14). Specimens were sampled from the log layers and decking. The sample consists mainly of wood of older age. Individual specimens belonged to age group II, close to group III in terms of the number of rings. Spruce and Siberian pine were used. Log layers and most of the decking elements were made of wood of groups III and IV.

After comparing the growth series, two sets of relatively high and low values were identified (the overlapping area was 77–169 years): 1) Glk – 64–78 %; TBP – 4.5–8.6, and CDI – 30–55; 2) Glk – 63–75 %; TBP – 3.4–8.1, and CDI – 10–29. Calendar matching showed low values: CDI – 13–27 and *r* – 0.34–0.54. To resolve doubts about the dates, a comparison with other dated individual and generalized series was made. One result of the search for correspondences was provided by synchronization of the generalized series of "log layers" with values confirming reliability of dating results (the overlap area was 185 years): Glk – 73 %; TBP – 10.4, and CDI – 79. Taking into account the ratio of dates of subcrustal and peripheral rings, the year of 1748 is considered as the time of death for most of the trees. The earlier dates of peripheral rings, which was only among the decking elements, lagged 50–74 years behind.

This building has already been dated. It was reported that "the northern wall of building 6 was unearthed. Two logs taken from the building were larch". The dates of the specimens corresponded to the autumn–winter of 1676/77 and 1678/79 (Gurskaya, 2008: 219), which does not agree with our results. The reason for this discrepancy may be that these elements might have belonged to different parts of the building.

Building 9A. The remains of this building were under building 9 (Fig. 7). Specimens were sampled from the elements of log layers and deckings. The log layers were made of spruce and Siberian pine; the trees belonged to age groups III and IV. Some decking elements were made of larch, although spruce was predominant. Most of these elements were made of trees of group II.

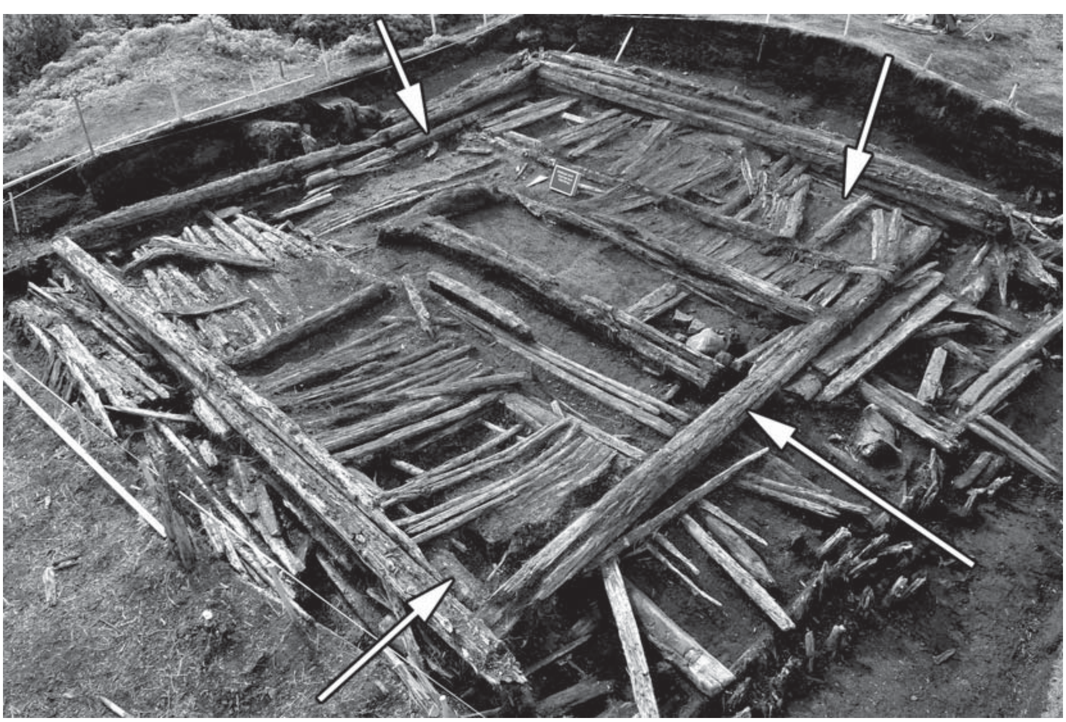

Fig. 7. Mutual position of buildings 9 and 9A (arrows indicate the elements of the log layers of building 9A). *Photo by A.V. Novikov*.

According to the results of the relative dating, only the growth series based on specimens from the log layers showed sufficiently high values of indicators: Glk – 71–80 %; TBP – 4.9–7.3, and CDI – 36–48. Subcrustal rings were not reliably identified. Comparison of other series, both with each other and with series based on the log layers, showed ambiguous results, which might have been largely caused by the predominance of specimens from relatively young wood. Acceptable values of indicators showing the quality of synchronization were as follows: Glk – 67–80 %; TBP – 4.3–7.1, and CDI – 30–48.

Absolute dating has shown low values (CDI – 26–40, *r* – 0.39–0.52), except for a single series (CDI – 84, and *r* – 0.76). A comparison with other dated series was made to resolve doubts about the dates. The dates of log layers were confirmed by greater values (CDI – 56–72). Taking into account the fact that subcrustal rings were either absent in the specimens from the log layers, or their presence was doubtful, the estimated time of death of the trees for the log cabin was the turn of the 17th–18th centuries (the latest date was 1698). Timber for some of the decking elements was harvested in the autumn–winter of 1701/02. The latest dates (1741–1742) were manifested by the elements of decking in front of the entrance, which resulted from the renovation of this part of the room.

Building 10. Seven specimens were obtained from log layers; two were taken from the filling; three more specimens belonged to a conventional "lower" log cabin, of which the corner of the lower log layer and a log supporting it have survived under the walls of the main structure (Fig. 8). Specimens from the elements of the main structure belonged to spruce; specimens from the "lower" log cabin were larch. Trees of age groups II–IV were used; the vast majority of them were about 90 years of age.

Comparison of growth series for the main structure demonstrated relatively high values of indicators: Glk – 65–84 %; TBP – 4.5–8.3, and CDI – 33–65. Five series based on specimens from the log layers were synchronized by one year. The dates of the peripheral rings lagged behind by one and three years. This sample contained specimens both with and without subcrustal rings. However, the narrow interval of distribution of dates suggests that all the timber for the log layers was harvested at the same time. A high degree of similarity was revealed by individual series based on the specimens from the "lower" log cabin (CDI – 45–65). They were synchronized by one year, 65 years earlier than the main group of dates.

Absolute dating of elements from the "upper" log cabin has revealed relatively low values of indicators (Glk – 61–67 %; TBP – 4.3–6.2, and CDI – 19–40), but was confirmed by the data of the COFECHA program (*r* – 0.47–0.61). Unambiguous results were obtained for the "lower" log cabin: CDI – 62–72, and *r* – 0.74–0.79.

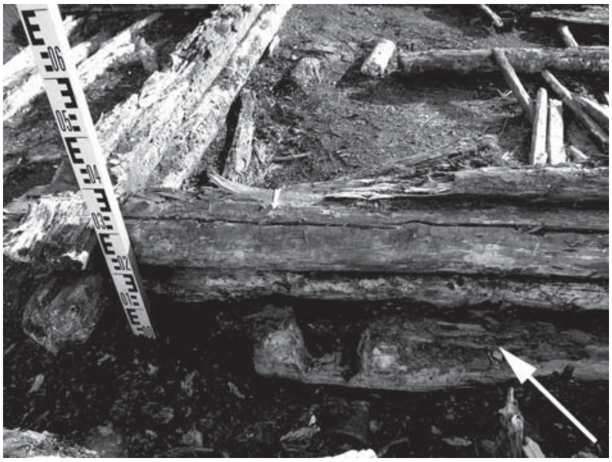

Fig. 8. Mutual position of the wall in building 10 and log layer of the "lower" log cabin (indicated by an arrow). *Photo by Y.N. Garkusha*.

Thus, most of the trees for the layers of the "upper" structure were harvested in the autumn–winter of 1742/43, while the trees for the "lower" structure were felled in the autumn–winter of 1677/78 (Fig. 9).

Discussion

When interpreting dendrochronological dates, the degree of reliability is established from the representativeness of the sample. In the case of archaeological structures that have been preserved fragmentarily, the judgments proposed *a priori* are accompanied by various assumptions. Analysis of the distribution of dates of specimens from the sample under discussion indicates the purposeful harvesting of the timber for construction. This primarily applies to wood used for the log layers. The degree of incorporation of reused material into other structural elements was probably chosen directly during the construction.

If the date of tree death falls during the autumn–winter period*, the end of the winter season is traditionally taken as the felling time. Thus, if the date of the subcrustal ring is suggested to be "the autumn of year n – winter of year $n + 1$", the year "$n + 1$" can be justifiably taken as the cutting time. This is important for interpreting dendrochronological dates.

We assume that freshly cut wood, that is wood harvested in the year "$n + 1$" corresponding to the dates of the main part of the elements, in particular log layers, was used for construction. This was the common practice in building traditions used in various cultures from the

*Based on the structure of subcrustal rings, the vast majority of trees from the sample under discussion were cut during that period.

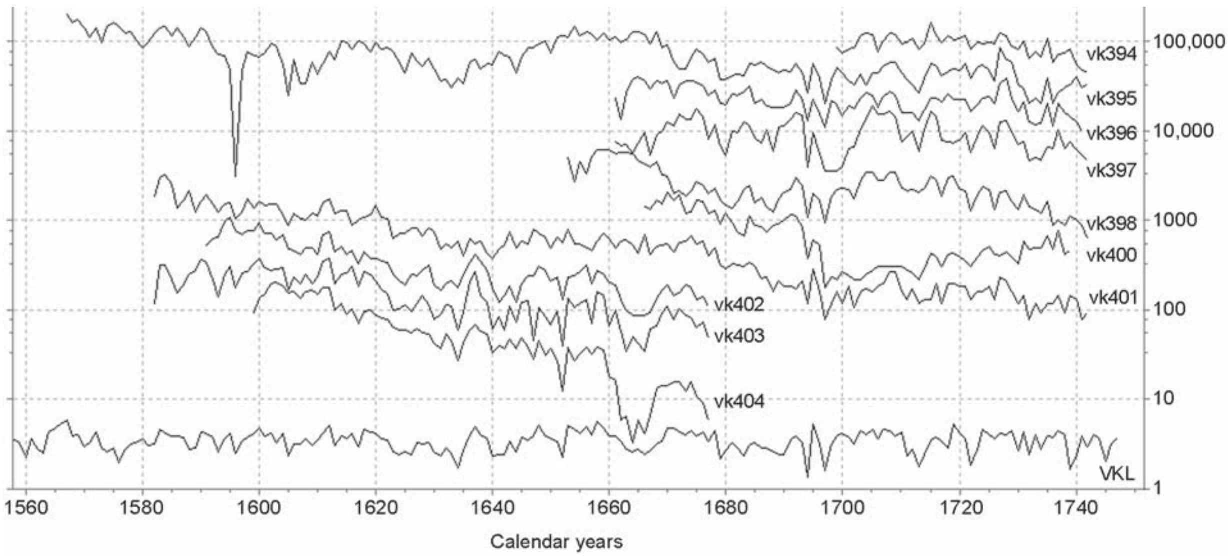

Fig. 9. Cross-dating of individual series based on the specimens from the "upper" (vk394–vk398, vk400, and vk401) and "lower" (vk402–vk404) log cabins in building 10.

Middle Ages to the Modern Age (Chernykh, 1996: 58–59). For example, most of the landmarks of Russian wooden architecture of the 17th–18th centuries were built using raw timber*. This is confirmed by the comparison of dendrochronological data and information from the written sources, as well as by construction techniques (Chernykh, 2001: 117–118; Maltsev, 2005).

Occurrence of parts (primarily from the log cabin walls) made of wood that was harvested during different seasons of the same year in the same building was a sign of such a practice at the Ust-Voikary settlement. A vivid example was building 8*: the dates of eight out of 15 specimens from the layers fell during the autumn–winter of 1639/40, while seven specimens were dated to the summer of 1640 (Gurskaya, 2008: 219). This approach to construction among the peoples of Western Siberia, in particular among the Ob Ugrians, is still practiced even today (Perevalova, Karacharov, 2006: 258, 268). Considering all the above, we will offer some arguments as to the time of constructing the buildings under discussion.

Building 1 was made in 1690. Specimens with later dates have not been found.

Building 2 was erected in 1553–1554. A later date shown by the wood from the filling was 1569. This gives grounds for assuming the time when this building functioned. This building was covered by a structure in the late 1570s.

Building 3 was presumably made in 1514. Specimens with later dates have not been identified. This structure was covered by building 2.

Building 3A was made in 1467. Specimens with later dates have not been identified. This structure was covered by building 3.

Building 5 was probably made in 1467 or a little later. There were no specimens with later dates in the collection.

Building 7 was made in 1739. The latest date of 1748 was revealed by a series of specimens.

Building 9 was probably made no earlier than 1748. Specimens with later dates have not been found.

Building 9A was built at the turn of the 17th and 18th centuries. The latest dates of 1741–1742 were revealed by a series of specimens. This structure was covered by building 9.

Building 10 was made in 1743. Specimens with later dates are absent in the collection. This building was probably located on the remains of an earlier log cabin presumably made in 1678.

Gurskaya obtained the following dates for other log buildings at the Ust-Voikary settlement (2008): 3* – ca 1666, 4* – 1647, 8* – 1640 (existed until the late 1680s, possibly until the beginning of the second third of the 18th century), and 9* – 1640 (before the beginning of the 1670s). The comprehensive publication of 2008, which was mentioned above, has no information on the dating of building 5*, but this information was available in an earlier article by Gurskaya, where larch specimens from the wall were dated to 1600. Other information was not provided (Gurskaya, 2006a). The publication of 2008 on building 7* reported that 19 specimens were sampled, but it was not possible to obtain reliable dates for them (Gurskaya, 2008: 219). However, in the article of 2006, this building was dated to 1652. Its filling contained wood with the cutting date of 1542 (Gurskaya, 2006a).

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*The emergence of log construction technology in northwestern Siberia is traditionally associated with the influence of the population from the European part of Russia.

The list of dated buildings shows that log cabins in the settlement have been known from the second half of the 15th century. Most structures date back to the end of the first half of the 17th century. The distribution of dates, which has been determined, only demonstrates a significant irregularity in studying different stratigraphic levels.

The correlation of types, chronology, and the excavated area of buildings make it possible to conclude that by the end of the first half of the 18th century, log architecture replaced stationary frame-and-post buildings, and already in the second half of the 18th century intense construction activities at the settlement ceased. Only two buildings on the hilltop are known which are dated later than the mid 18th century (according to archaeological data, not earlier than the early 19th century) (Fedorova, 2006: 15–16). Therefore, their emergence is associated with another page in the history of this settlement.

Conclusions

The Ust-Voikary fortified settlement, a stratified site of the Middle Ages/Modern Age, left by the indigenous population from northwestern Siberia, is one of the few archaeological sites known in the region with a cultural layer preserved in permafrost. The results of its in-depth study provided in the literature and in this article are only relevant for a limited part of the settlement on a hill of artificial origin, where excavations have been carried out.

Log buildings were the object of this study. Using the method of dendrochronology, dates were obtained for nine structures examined in 2012–2016. When interpreting the dates, the author proceeded from the assumption that freshly cut wood was used for construction. Generalization of dendrochronological data has shown that already in the second half of the 15th century, log buildings coexisted with frame-and-post buildings in the structure of the settlement. New evidence has made it possible to clarify the upper boundary of active construction at the settlement—the end of the first half of the 18th century. After that, construction activities began to decrease.

The architecture of the final stage of the history of the settlement makes it possible to speak about the replacement of stationary frame-and-post buildings with log cabins. Gradual and probably complete transition to log construction distinguishes the Ust-Voikary settlement from two other well-known, large settlements in the region—the Nadym and Polui fortified settlements. The later stages in the history of all these settlements were generally synchronous. However, log construction in the Nadym and Polui fortified settlements in this period was not well developed. It was used only for building small dwellings, forming territorially isolated and relatively small peripheral areas in the structure of the settlements (Kardash, 2009: 65–67; 2013: 130–131).

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